TENNESSEE VALLEY AUTHORITY
ENVIRONMENTAL REPORTS

HARTSVILLE NUCLEAR PLANTS

VOLUME 3

THIS SIDE
TO SHEETS

8.0 Economic and Social Effects of Plant Construction and Operation

This section provides an overall assessment of the economic and other benefits of the Hartsville Nuclear Plant and the economic and environmental costs.

TVA from its very inception has been deeply committed to the tasks of environmental improvement. The President in transmitting to Congress in 1933 the bill that became the TVA Act said that TVA ". . . should be charged with the broadest duty of planning for the proper use, conservation, and development of the natural resources of the Tennessee River drainage basin and its adjoining territory for the general social and economic welfare of the Nation." It is on the basis of these principles that TVA plans and conducts all its activities, be they planning, constructing, and operating a nuclear power plant; planning, building, and operating a water control project; providing research to develop a new fertilizer; setting aside areas for fish and wildlife; developing improved hardwood tree strains; or seeking ways to utilize the rugged scenic qualities of some of the region's natural streams. In all of these and many other varied resource development programs, TVA is deeply conscious of its responsibilities to the people in the TVA region and in the Nation. This posture invariably calls for a balancing of a variety of interests and, finally, decision and action in which differences are reconciled insofar as possible to best serve the needs of the greatest number over the longest possible time. Inherent in this is the requirement of finding a balance between the needs of man, including his need for useful employment, and the safeguarding of his physical environment.

In TVA electric power is regarded as a tool for economic development. Its use has been encouraged as a means for improving the quality of life in the region. Fitted into a comprehensive, unified development program, it has helped ease the burdens of drudgery; provided more jobs and more productive employment; brought the amenities of life to an ever-increasing number of people; and generally improved the health, education, and living conditions of the people.

An ample supply of low-cost electric energy, integrated with a total resource development program, has been a major factor in the progress achieved by the TVA region since 1933. Employment, income, and productivity have all increased with a shift from a primarily agricultural to an industrial economy.

The uses of electricity are many. To the residential user it provides lighting, refrigeration, cooking, washing and drying of clothes, heating, air conditioning, and education and entertainment via radio and television, to name but a few. Most stores, banks, and other commercial ventures are dependent on electricity for conducting business. In industry it is an essential element by which productivity has been increased with an attendant improvement in living standards. While in most industrial activities the cost of electric power is a small fraction of the total cost of production, without electricity modern industry could not provide the Nation with the goods and services it demands. In the aluminum, electrochemical, and metallurgical industries, electricity is a significant component required in the manufacture of these essential products.

The addition of the Hartsville Nuclear Plant to the TVA system will enable TVA to continue to carry out its responsibility to provide an ample supply of electricity for the TVA region. The benefits of the plant include the value of the electrical power to be generated, including a stimulation of the economic growth of the region, helping to assure increased employment potentials; the potential for reduction of releases of combustion products to the atmosphere which would be associated with fossil-fired generation; the recreational and educational value to visitors to the plant; and increased payments to local governments in lieu of tax payments.

The costs of the plant include the commitment of about 1,940 acres of land for the lifetime of the plant; the rejection of about 3.24×10^{10} Btu/h to the air directly and via Old Hickory Reservoir from cooling tower blowdown; the consumptive use by evaporation of about 111 ft^3/s of water; minor releases of radioactivity to the air and to Old Hickory Reservoir; erosion of soil during construction; a very low probability of releasing radioactivity due to an accident in the plant or an accident during the transport of radioactive materials; and the monetary costs to construct, operate, and maintain the plant.

TVA has attempted, insofar as practicable, to detail those items covered in the Atomic Energy Commission's Regulatory Guide 4.2, Preparation of Environmental Reports for Nuclear Power Plants (issued March 2, 1973) for the benefit-cost analyses for this facility in Sections 8.1 and 8.2 and these are summarized in Section 11.0. The weighing and balancing of benefits and costs of alternative generation, sites, and subsystems is presented in Sections 10.0 through 10.12.

While various benefits and environmental costs have been quantified, some are necessarily expressed in qualitative terms. For example, the effect of natural draft cooling towers on aesthetics is treated qualitatively. Moreover, of those factors subject to quantification, all cannot reasonably be expressed in monetary values. Although the number of Btu's added to the cooling water blowdown can be numerically quantified, translation of that number to a monetary value is not reasonable in view of the wide range of variables influencing the significance of the impact. Environmental impacts, therefore, are quantified in commonly used terms such as numbers of fish, gallons of water, and tons of earth.

In addition to analyzing the need for base-load electrical capacity additions, the Hartsville Nuclear Plant environmental review includes an analysis of the alternatives for limiting environmental impacts during the construction of the project and the environmental impacts which will result from operation of the plant. During this environmental review, the design concepts for the plant have been chosen so as to provide a plant which approaches a minimum impact plant. Specific system design concepts are discussed in Sections 10.0 through 10.12.

8.1 Benefits

The benefits of the Hartsville plant are detailed below and are summarized in Table 8.1-1.

8.1.1 Electric Power Produced and Sold - In order to report all of the benefits requested in the Atomic Energy Commission's Regulatory Guide 4.2, Preparation of Environmental Reports for Nuclear Power Plants, TVA has included the benefits inherent in the value of the electricity generated by the plant even though the dollar value presented does not provide an exact measure of the benefits due to generation of this power.[1] The Hartsville Nuclear Plant includes four units, with a total dependable capacity of 4,680 MW electrical. The four units are scheduled for commercial operation on the following dates: the first unit in December 1980; the second unit in June 1981; the third unit in December 1981; and the fourth unit in June 1982. Since capacity is planned for on a system basis, it is not possible to identify the specific loads which the Hartsville nuclear units will serve. For the purpose of the benefit analysis, it has been assumed that the plant serves loads based on the incremental increase in loads for each class of customers estimated between fiscal year 1973 and fiscal year 1981. The estimated peak load and sales for these years are identified in the following table.

	F.Y. 1973		F.Y. 1981		Increase	
	Actual Load	Percent of Total	Estimated Load	Percent of Total	Load	Percent of Total
Peak Demand (MW)	18,888	--	30,900	--	12,012	--
Estimated Sales (Million kWh):						
Residential	30,637	29.6	48,649	28.8	18,012	27.6
Commercial	12,908	12.5	24,322	14.4	11,414	17.5
Industrial	37,085	35.8	58,023	34.4	20,938	32.0
Government	18,259	17.7	30,282	17.9	12,023	18.4
Other Sales	4,584	4.4	7,534	4.5	2,950	4.5

The value of a unit of electric energy to the user varies widely, depending on the availability and cost of alternative energy sources. No attempt is made to identify such values in this analysis. However, the price customers now pay for electric energy establishes a measure of the value to the user. Based on the present rate structures of TVA and the distributors of TVA power, the following average prices to the ultimate consumer are estimated.

Residential	1.519¢/kWh
Commercial	1.421¢/kWh
Industrial	0.933¢/kWh
Government	0.788¢/kWh
Other	1.276¢/kWh

For the purpose of estimating the present value of the revenue received from the sale of this energy, it has been assumed that the Hartsville plant will operate as shown in the following table during its 35-year generating life.

Years	Capacity Factor	Annual Net Generation (Million kWh)	Total Transmission and Distribution Losses (Million kWh)	Annual Energy Available For Sale (Million kWh)
1-15	80%	32,797	2,302	30,495
16-25	55%	22,548	1,584	20,964
26-35	40%	16,399	1,152	15,247

Using the energy available for sale and the current prices paid for electricity shown above, a discount rate of 8 percent, and the assumption that all units operate for the same time period, a value of the sales from the plant is estimated and presented in the benefit description form. The results are summarized below.

Levelized Annual Energy Generation (kWh)	$29,555 \times 10^6$
Levelized Total Annual Losses (kWh)	$2,075 \times 10^6$
Levelized Annual Energy Available for Sale (kWh)	$27,480 \times 10^6$

	Average Annual Energy Available For Sale - kWh	Value of Sales During Plant Life 1981 Dollars	Average Annual Value - Dollars
Energy Sold:			
Residential	$7,585 \times 10^6$	1,343,000,000	115,200,000
Commercial	$4,809 \times 10^6$	796,000,000	68,300,000
Industrial	$8,794 \times 10^6$	956,000,000	82,000,000
Government	$5,056 \times 10^6$	464,000,000	39,800,000
Other	$1,236 \times 10^6$	184,000,000	15,800,000
Total Sold	$27,480 \times 10^6$	3,743,000,000	321,100,000

Historically, electricity rates declined until the mid-1960's. Events of more recent years have caused this trend to reverse. Higher prices for fuels, higher interest rates, increases in construction costs, and costs of pollution control equipment have been significant factors causing the increases in rates for electric utilities. It was necessary for TVA to increase its rate schedules in 1967, 1969, 1970, 1973, and 1974. The effect of these rate increases has resulted in the average cost of electricity to the consumer increasing by 85.9 percent. Thus, the use of current rates throughout projected plant life could significantly understate the future sale price.

8.1.2 Payments in Lieu of Taxes - Estimates of payments in lieu of taxes include estimates of payments to state and local governments by TVA and by distributors of TVA electricity. Estimates are based on current rates of payment related to the energy which will be generated by the plant. An estimated $14.1 million per year will be paid to the State of Tennessee.

TVA acquisition of the site land and construction of the nuclear plant will not have any effect upon TVA payments in lieu of taxes directly to the counties concerned under the provisions of Section 13

of the TVA Act as amended. The value of the generating plant site immediately upon acquisition and the book value of the plant itself as construction proceeds will be reflected in the calculation formula which determines the amount of the annual payment in lieu of taxes from TVA to Tennessee state government.

Under state law, TCA Sections 67-2401--2405, as amended, the State of Tennessee redistributes to counties and municipalities a portion of the TVA payment received by it. As now interpreted and administered, the state redistribution procedures provide for payments to local units based on the land only used for TVA generating plant sites. Such annual calculation calls for application of the utility assessment ratio (55 percent) to the TVA purchase cost of the generating plant site and then applying the current local property tax rate to the hypothetical assessment so derived to determine the amount of the state redistribution payment to the local unit. Such state calculations will take effect with respect to the first fiscal year beginning after official TVA designation of the land as a generating plant site. Since the land is now classed as farm land subject to an assessment ratio of 25 percent, and the TVA purchase cost will likely be well above the county property assessor's appraised value of the land as farm land, it is clear that the counties can expect a larger payment in lieu of taxes (from the State) because of this plant site than the amount of former farm taxes on the same land before TVA acquisition. The comparative former county taxes and estimated future payments in lieu of taxes to the respective counties for this property are set out in

Table 8.1-2. The estimated future payments in Smith County will be about six times the amount of present taxes on the site land, in Trousdale County over four times, and nearly five times for the two counties combined. The payments in lieu of taxes benefits will go to Smith and Trousdale Counties and the State of Tennessee.

8.1.3 Regional Gross Product - Benefits of the Hartsville plant to regional gross product cannot be exactly quantified monetarily. However, a correlation has been made of the average annual dollar flow of gross product with the use of the Hartsville electrical power in the TVA power service region. This correlation is based on using the average power generation and relationships between gross product and kilowatthours equivalent of all energy consumed. The industrial gross product factor was obtained as a product of the relationship between value added and kWh equivalent (Census of Manufacturers, 1967) and the relationship between gross product from manufacturing and value added by manufacturing (Census of Manufacturers, 1967 and Survey of Current Business). The numerical value of the industrial gross product factor was found by this method to be $0.0649 per kWh. The commercial gross product factor was obtained by comparing gross product from commercial activities and an assumed electrical energy output of 25 percent of total energy input to the commercial sector (Energy in the American Economy, 1850-1975, Schurr and Netschert). Numerical values of this factor were $0.187 per kWh for 1967 and $0.184 per kWh for 1969. Giving slightly more weight to the recent figure, $0.185 per kWh was selected as the commercial gross product factor. Industrial power consumed was assumed to include government

use of electrical energy. The resulting average annual dollar flow of gross product is estimated at about $1.787 billion.

As noted above, no additional quantification to arrive at a monetary benefit is considered possible. This is because the comparison of dollar value of products produced and energy consumed does not consider other variables in the production of products, such as wages of workers and efficiencies of individual production processes. It should be noted that a plentiful energy source has long been considered essential in the economic and industrial expansion of any region. As required by the TVA Act, as amended, TVA maintains an ample supply of electrical energy in the area in which it conducts its operations. A comparison of statistics in the TVA region with national statistics implies there are some beneficial effects of this plentiful energy source. In 1960 gross regional product was 2.26 percent of national; in 1970 this had increased to 2.69 percent. In 1960 personal income in the region was 64 percent of the national value; in 1970 this had increased to 75 percent. TVA considers that the ample availability of electricity as an energy source has helped realize these growth rates. This will be a benefit for the entire region in the TVA system, the southeastern U.S., and the Nation.

8.1.4 Recreation - The recreational benefits of the proposed visitors' center at the Hartsville site are estimated at 15,000 visits per year. This estimate of recreational visits is in addition to the estimate of educational visits to the plant, which is given in Section 8.1.7. At a value of $0.75 per visit[2], the annual value of these visits is estimated to be $11,000. The persons making the visits to the plant will receive this benefit.

8.1.5 Air Quality - Since the Hartsville plant is a baseload plant, approximately 8.8 billion kWh will be available during the baseload period to replace coal-fired generation which would otherwise have consumed about 4 million tons of coal per year. This will result in annual reductions in particulate emissions of about 3,600 tons, SO_2 emissions of about 235,000 tons, and NO_x emissions of about 36,000 tons when based on replacing coal-fired generation which uses coal of the quality now being burned and current technology. This will benefit the people in the TVA area.

8.1.6 Employment - Benefits to employment have been listed as the average annual number of workers whose jobs could be related to the consumption of electrical power produced by the Hartsville plant. An industrial employment factor, relating kWh equivalent consumed in manufacturing to employment in manufacturing, was determined from national data from the Census of Manufacturers, 1967. A value of 5.4588 workers per million kWh was obtained. A commercial employment factor was obtained by analysis of data from Energy in the American Economy, 1850-1975, by Schurr and Netschert. For 1967, this relationship was 14.83 workers per million kWh; for 1969, 13.39 workers per million kWh. The intermediate value of 14 was chosen for estimating the commercial portion of the employment value listed. Based on the portion of the Hartsville Nuclear Plant generation allocated to commercial and industrial use, the potential exists for expanding the number of new jobs by about 142,800. This will affect the entire region in the TVA system. Employment at the project will consist

of temporary construction personnel and permanent plant personnel. The estimated average annual 1974 wage for such a construction force is about $13,300; and the estimated average annual 1974 wage for a member of the plant staff is approximately $13,000. Estimates of total wages which will be paid to the construction force during the construction period is about $373 million. Annual income for the permanent plant staff is estimated to be about $4.5 million. The area that receives this benefit will be the area where the workers and their families live, primarily within commuting distance of the plant site.

8.1.7 Education - The educational benefits of the Hartsville plant are estimated to be 55,000 visits per year after the plant is operational. The annual value of these visits, at $1.90 per visit[3], is $104,500. Educational visits by persons to the plant during its construction are estimated to be about the same number as after the plant is operational. The persons receiving this benefit will be those persons who visit the plant.

As a result of the mitigation program outlined in Section 4.2, some impacted school systems may have permanent facilities with less capital outlay than they would have without the project. This capital contribution by TVA will be the equivalent of the necessary expenditures for temporary facilities. The amount will be determined in part by further studies on estimated impacts and part by what impacts are actually experienced.

8.1.8 Aesthetics - As discussed in Section 3.1, the design of the plant will utilize the natural topography of the site, construction material, structure placement, and landscaping to make the plant as attractive as possible to result in the minimum practical visual impact on the surrounding area.

REFERENCES FOR 8.1

1. Vermont Yankee Nuclear Power Corporation (Vermont Yankee Nuclear Power Station), ALAB-179, RAI 74-2, 159, 172-76 (February 28, 1974).

2. "Establishment of Principles and Standards for Planning Water and Related Land Resources," Water Resources Council, October 25, 1973.

3. Calculations based on "State of Tennessee, Annual Statistical Report of the Department of Education for the Scholastic Year Ending June 30, 1973."

Table 8.1-1

HARTSVILLE NUCLEAR PLANT - BENEFITS

Direct Benefits	
Expected Levelized Annual Generation in Kilowatthours	29,555,000,000
Dependable Capacity in Kilowatts	4,680,000
Proportional Distribution of Electrical Energy - Expected Levelized Annual Delivery in Kilowatthours:	
Residential	7,577,000,000
Commercial	4,805,000,000
Industrial	8,786,000,000
Government	5,052,000,000
Other	1,235,000,000
Annual Revenues from Electrical Energy Generated in Dollars	
Residential	115,200,000
Commercial	68,300,000
Industrial	82,000,000
Government	39,800,000
Other	15,800,000
Indirect Benefits	
In Lieu of Tax Payments (Local, State), Dollars/Year	14,100,000
Regional Product	See Text
Environmental Enhancement	
Recreational	
Visitors' Center, Dollars/Year	11,000
Air Quality (Potential to Reduce Pollutants in Tons/Yr)	
SO_2	235,000
NO_x	36,000
Particulates	3,600
Employment	
Potential Jobs Provided	142,800
Annualized Income by Construction Force, Dollars	32,500,000
Annual Income by Permanent Plant Personnel, Dollars	4,580,000
Education - Dollars/Year	104,500

Table 8.1-2

HARTSVILLE NUCLEAR PLANT
FORMER COUNTY TAXES ON LAND COMPARED WITH ESTIMATED
FUTURE PAYMENTS IN LIEU OF TAXES

Explanation	Smith County	Trousdale County	Total 2 Counties
Assessed valuation of land (25% assessment ratio)	$ 40,205	$117,283	$ 157,488
Tax rate per $100, 1973	2.85	2.15	-
Amount of county taxes, 1973	$ 1,146	$ 2,522	$ 3,668
TVA appraised value of property	$438,064	$910,936	$1,349,000
Estimated in-lieu-tax base (55% assessment ratio)	$240,935	$501,015	$ 741,950
Assumed tax rate (same as 1973)	2.85	2.15	-
Estimated in-lieu-tax payment distributed to counties by state	$ 6,867	$ 10,772	$ 17,639
Excess of in-lieu payment over former taxes	$ 5,721	$ 8,250	$ 13,971

8.2 Costs

The economic and social costs associated with the Hartsville Nuclear Plant are addressed below in two parts--Internal Costs and External Costs.

8.2.1 Internal Costs - An appraisal of the primary economic costs resulting from facility construction, operation and maintenance, and decommissioning is discussed below and presented in table 8.2-1. All cost information is expressed in 1981 dollars, regardless of the year in which the expenditure is made utilizing an escalation rate of 5 percent, an interest rate of 8 percent, and a 35-year life of plant. The escalation rate is based on previous TVA experience with the construction and operation of other steam plants, and the interest rate is an estimate based on TVA financing methods.

The items and their costs that make up the internal cost for this plant are: (1) Capital cost of land acquisition and improvement. (2) Capital costs of facilities construction. (3) Plant decommissioning costs (a discussion of decommissioning is contained in section 5.9). (4) Capital costs of plants distribution and transmission facilities. (a) Distribution facilities (this cost is also contained in the capital cost of facilities construction). (b) Transmission facilities. (5) Present worth fuel costs. These costs include fees for disposition and reprocessing the spent fuel, as well as credits for recovered plutonium and uranium. (6) Operating and maintenance costs. These costs do not include payments in lieu of taxes or other annual fees. (7) Fees. (a) Application fee. This will be paid in 1974. (b). Construction permit fee. This will be paid in 1975. (c) Operating

license fee. This is assumed to be paid in 1981 for all units. (d) Present worth annual fees. (e) Present worth estimated payments in lieu of taxes. The total present worth generating cost is $3,091,043,000.

8.2.2 External Costs - The external costs are those social and economic costs resulting from constructing and operating the proposed plant. These costs are divided into temporary external costs and long-term external costs for discussion below in Sections 8.2.2.1 and 8.2.2.2, respectively.

While various benefits and costs have been quantified, some are necessarily expressed in qualitative terms. Of those factors subject to quantification, all cannot reasonably be expressed in monetary values; therefore, environmental and social costs are, for the most part, quantified in commonly used units such as numbers of fish, gallons of water, and tons of earth.

8.2.2.1 Temporary External Costs - The temporary external costs are primarily those related to construction and are not expected to last past the end of construction and a short readjustment period thereafter. An indication of these costs is given below and discussed in Section 4.2.

Employment at the project will range from approximately 1,200 employees after the first year to a peak of about 4,600 after the fourth year. Of these employees, those moving into the vicinity of the Hartsville project are estimated to be about 300 after the first year and about 2,600 at the peak of employment. The total population and school-age population increase associated with these

employee movers are estimated to be 6,000 and 1,700, respectively, at the peak of employment.

Housing - As discussed in Section 4.2, the influx of construction workers will stress the available housing market and potentially create localized land use conflict in the area of the plant. During peak employment, the housing demand is estimated to be for about 2,000 dwelling units. Based on past experience, mobile homes may comprise one-half or more of the housing occupied by construction workers, or about 1,000 at peak. This would leave a demand of 1,000 conventional dwelling units. The conventional housing needs are expected to be met primarily in Wilson and Sumner counties. (See Section 4.2) Most mobile homes are expected to locate in close proximity to the site in Smith, Trousdale and Macon counties.

Traffic - State Highway 25 had an average daily traffic (ADT) load of about 2,100 vehicles in 1972. The capacity of this type road ranges from about 3,500 to about 5,000 ADT. Peak construction traffic would add about 2,600 to the ADT which may result in a temporary overload condition from an ADT standpoint. From an hourly standpoint, this type of road can accommodate from 1,150 to 2,000 cars per hour. Therefore, the highway is likely to be able to accommodate the estimated 1,500 cars associated with the change of the day shift, particularly since the construction traffic from the site will be divided between the east and west directions on the highway. An access road will be available at each end of the site, which should reduce traffic conflicts. However, there will be some congestion in the towns of Hartsville to the west and Carthage to the east of the site since some workers will commute from beyond these towns and must pass through them.

9.1

9.2

9.3

Health Facilities - In May 1973, only one physician was practicing in Trousdale County and six in Smith County. Three small, unaccredited hospitals serve the area; the Hartsville General Hospital with 34 beds; the Carthage General Hospital with 29 beds; and the Smith County Hospital with 43 beds, one coronary care unit, and one intensive care unit. Emergency medical services (EMS) are being improved in Trousdale County as part of a program of the Mid-Cumberland Health Planning Agency.

Relocation - Eleven households now residing on the site will need to be relocated and two households in the path of the proposed access railroad. However, as discussed in Section 4.2, these families are entitled to certain assistance.

8.2.2.2 Long-Term External Costs - These costs are those social and economic costs that will be associated with the operation of the Hartsville Nuclear Plant.

Location of the plant, because of its size, will change the aesthetic and scenic values in the immediate vicinity of the plant. A discussion of these values and composite drawings are contained in Section 3.1.

Construction of the plant on this site will result in the removal of most of the 1,940 acres contained within the site from active farming. The site will be used for electrical generation at least for the life of this plant. A discussion of these changes is contained in Section 5.8.

Construction of the transmission lines will involve about 5,400 acres of land. Use of this land will be affected in that it will be restricted to those uses not interferring with line operation and maintenance. Multiple uses of rights of way are discussed in Section 5.6.3. The 2,311 acres of the rights of way now in forest must be considered to be removed from forest production.

The access railroad will require about 75 acres of land. This land will be removed from its present use for at least the life of the plant.

Operation of the natural draft cooling towers will result in a water vapor plume that would normally be visible over a wide area. This should create no impacts offsite other than visual. However, fog resulting from the small amount of heated discharge into the river will affect river traffic for approximately 497 hours per year.

Costs to local governments for increased services for the permanent employees have not yet been quantified.

TABLE 8.2-1

HARTSVILLE NUCLEAR PLANT
INTERNAL COSTS
(1981 Dollars)

Type of Cost	Cost
Capital Cost of Land Acquisition and Improvement	$ 3,000,000
Capital Cost of Facilities Construction	1,572,000,000
Plant Decommissioning Costs*	125,000,000
Capital Cost of Plants Distribution and Transmission Facilities	
Plants Distribution Facilities*	58,000,000
Transmission Facilities	114,000,000
Present Worth Fuel Costs*	781,421,000
Present Worth Operating and Maintenance Costs*	281,467,000
Fees	
Application Fee*	214,000
Construction Permit Fee*	2,217,000
Operating License Fee*	3,730,000
Present Worth Annual Fees	28,636,000
Present Worth Estimated Payments in Lieu of Taxes	164,328,000

*See text, section 8.2.1.

9.1

9.2

9.3

10.0 Plant Design Alternatives

9.1 Alternatives Not Requiring The Creation of New Generating Capacity

9.1.1 No Action - As discussed in section 1.3, the power supply situation is expected to be extremely tight during the 1980-82 period even with the planned addition of the Hartsville generating units. Any delay in the operation of these units or a decision not to plan for the forecast increase in power demands could result in the inability of the TVA system to adequately meet its load obligation and could jeopardize the reliability of the system and indeed the region.

Also, a decision at this time not to commit to serve these power demands would preclude the consideration of nuclear generation as an alternative for the 1980-82 period because of the long lead time requirements. As is discussed later in this chapter, nuclear generation offers substantial benefits from both the standpoint of economics and environmental impacts.

The alternative of taking no action to serve the power needs of the area is therefore considered an unacceptable alternative.

9.1.2 Purchased Power - The power demand and supply situation of neighboring utilities has been reviewed as given in FPC Region IV Reliability Council reports, and it has been concluded that the magnitude of TVA's power demands in the early 1980's could not be supplied by purchased power from neighboring utilities with their currently planned capacity additions. Furthermore, to supply equivalent amounts of power and energy on a year-round basis to TVA, another large electric utility with extensive transmission interconnections would have to install generating capacity in amounts slightly greater than that of the Hartsville

Nuclear Plant, build several high-capacity transmission lines to the TVA area, and transmit the power to TVA. To construct such facilities on another power system would not avoid an impact on the environment but would only create an environmental impact in another area. Even if the assumption is made that the plant locational factors and costs would be equal, the cost of transmission lines, the transmission line losses, the use of land for transmission line rights of way, and the exposure to transmission line outages would result in waste of natural resources, materials, and funds, and would provide a more costly and less reliable source of power for the TVA region than will the construction of additional TVA generating facilities. Therefore, the purchase of electric power is considered as an unavailable and unacceptable alternative.

9.1.3 Reactivation of Older TVA Generating Facilities - TVA has no old generating equipment which has been retired with the exception of some very small hydro units which were no longer serviceable. The Watts Bar coal-fired plant which was placed in service in 1942 had been placed in standby condition, but TVA recently reactivated this plant and placed it in active service. This alternative is not available to TVA.

9.1.4 Operating Existing Peaking Capacity as Base Load - Operating TVA's peaking capacity as baseload would generate more kilowatthours during the offpeak periods, but these facilities are already needed to provide an adequate supply during the peak load periods. Thus, this alternative would not provide the required reserve needed in the future nor would it serve the projected increase in power demands and is therefore not feasible.

10.1 9.2 9.3

10.0 Plant Design Alternatives

9.2 Alternatives Requiring The Creation of New Generating Capacity

9.2.0 Introduction - TVA's generation planning studies consider maintaining a practical mix of conventional hydro, pumped-storage hydro, gas turbine, fossil-fired, and nuclear generating units. TVA presently has a large hydro system which supplies an important amount of peaking capacity, and will have a 1,530-MW pumped-storage project (in 1975) and over 1,000 MW of gas turbine peaking capacity on its system before the 1980-82 generation is needed.

Studies of the system load characteristics and the characteristics of the existing generating facilities indicate that the installation of additional pumped-storage or other peaking capacity is not an economical alternative in the 1980-82 period. The system needs, as indicated by TVA planning studies, required that detailed comparisons be made between baseloaded alternatives.

9.2.0.1 Baseloaded Alternatives - The use of hydroelectric units was eliminated as an alternative because there are no hydroelectric sites in the TVA service area suitable for baseload hydroelectric generation in the amount required to serve the capacity and energy demands of this time period. Based on the following excerpts from U.S. Geological Survey Circular 647, "Classification of Public Land Valuable for Geothermal Steam and Associated Geothermal Resources," geothermal energy is not considered as a feasible alternative for the TVA area.

> Geothermal areas of the United States are found primarily in the western states, along the circum-Pacific belt of young volcanism and mountain building and where the Pacific ridge system (a locus of high heat flow) intersects the North American continent along the Gulf of California and the Imperial-Coachella Valley of California. In the Eastern United States, potentially economic reservoirs of geothermal heat have been identified in the deep parts of the Gulf of Mexico sedimentary basin.

> For a geothermal reservoir to have appreciable potential for exploitation, it must meet the following requirements: (1) relatively high temperature (greater than 150°-400° F., depending on processing technology), (2) a depth shallow enough to permit drilling (currently 10,000 ft or less), (3) sufficient rock permeability to allow the heat transfer agent (water and/or steam) to flow continuously at a high rate, and (4) sufficient water recharge to maintain production over many years.

Current estimates of the geothermal gradient in the TVA area are less than 1° C. per 100 feet. On this basis, depth to heated rock would exceed that given above by U.S.G.S. for potential geothermal use. Thus, the potential for geothermal power in the TVA service area appears to be very low based on current knowledge of subsurface conditions in the area and certainly could not be relied upon to produce electricity in the quantity and time frame needed.

Thus, TVA's more detailed studies considered that the required generating capacity additions would be baseload fossil-fired, or baseload nuclear units.

9.2.0.2 Alternative Fuels - The assessment of alternative fuels which follows was made prior to the awarding of bids for the Hartsville units in December 1972, and is, therefore, based on information which was available at that time.

The Federal Power Commission, numerous speakers before congressional hearings, and private sources continue to forecast national shortages of natural gas in the 1975-90 period. The Federal Power Commission's Bureau of Natural Gas issued a report in February 1972 entitled "National Gas Supply and Demand 1970-1990" which states that the Nation's gas supplies from now until 1990 will be inadequate to meet current projections of future demand. Even with optimistic additions to

reserves and substantial imports, the report projects shortages of 9.5, 13.7, and 17.1 trillion cubic feet in 1980, 1985, and 1990, respectively.

Further evidence of the shortage of natural gas was exemplified by Mr. John N. Nassikas' testimony in hearings before the Committee on Interior and Insular Affairs on April 19, 1972, in which he stated:

> In my opinion, it is indisputable, and the evidence so indicates, that deliverable natural gas supplies have deteriorated to intolerable levels. Demand for natural gas has exceeded the most optimistic forecasts, and environmental considerations will further accelerate the requirements for this clean-burning fuel.

In line with this, TVA has also found a shortage of natural gas in the TVA area. TVA has contacted all major gas suppliers in the TVA area in recent years in hopes of securing a gas supply for 1,000 MW of gas turbines now installed on its system. No gas could be obtained for a year-round supply, and there was only limited success in obtaining a gas supply during the summer months.

In light of the above considerations, generating alternatives which use natural gas as a fuel source are not feasible because of the lack of assurance of a fuel supply.

<u>Oil</u> - The Department of the Interior, in its report, "U.S. Energy - A Summary Review" submitted in January 1972, projected the cumulative 1970-85 domestic demand for oil at 0.65 x 10^{18} Btu while the known U.S. reserves are 0.26 x 10^{18} Btu. The forecast also indicates an increasing dependence on imported oil. Recent estimates by the Department of the Interior indicate that, by 1985, 58 percent of U.S. domestic requirements will be supplied by foreign imports. Rogers C. B. Morton, Secretary of the Interior, before the April 10-13, 1972, hearings before the Committee on Interior and Insular Affairs stated:

> If our domestic resource base is not substantially broadened and improved, then we would look forward to something in the order of 50 percent of our oil requirements being imported.

Of this amount, Mr. Morton said 35 percent of the imported oil would have to come from the Middle Eastern countries.

The country's dependence on imported oil will not be improved by the resolution of the environmental questions associated with the development of offshore reserves and the transportation of oil from Alaska's North Slopes since they are included in the above estimates.

With specific reference to the ability of TVA to be able to assure a fuel supply for a large oil-fired plant, discussions have been held with three suppliers. The suppliers have indicated that the quantity of oil required to supply a plant (the size of the proposed) on a long-term basis would require that the supplier acquire an oil import quota each year. Throughout these discussions the suppliers indicated that a fuel supply of this magnitude would be contingent on a supplier's obtaining an oil import quota. Even if such a quota could be obtained, TVA would be in a position of relying on foreign oil for supplying the energy needs. Serious consideration of oil-fired plants would involve weighing of the long-term risks of such a supply, both in terms of the economic factors and the contribution of TVA power supply to the national security against any identifiable environmental benefits.

Coal - Coal is the most abundant domestic fossil fuel with a conservatively estimated[a] reserve level of 3.2 trillion short tons.

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a. United States Energy - A Summary Review, U.S. Department of the Interior, January 1972, p. 29.

To meet the SO_2 emission standards of Alabama and Tennessee, it is estimated that coal with a sulfur content of 0.7 percent or less would be required. Examination of the Nation's coal reserves meeting this requirement indicates that the vast preponderance of such coal is located in the western states in the form of subbituminous and lignite.

The subbituminous coal of this area is characteristically low-sulfur, high ash and moisture, and low heat content. The transport of this coal to the TVA area would involve distances in excess of 1,000 miles. TVA has conducted tests on an existing coal-fired unit using this coal and has found that there is a substantial loss in capability in units not specifically designed to burn this coal. Discussions with boiler manufacturers in August 1972 indicate that a substantially larger boiler would be required. The largest unit which has been designed to burn low-sulfur coal is about 750 MW.

In consideration of the available reserves, low-sulfur coal is considered as a feasible alternative; however, both the economic and environmental factors associated with the transportation of this coal become significant.

Medium-sulfur coal is available from local sources in the quantities required and at relatively economic prices. However, it is not clear at this point when the SO_2 removal technology will be available to reduce SO_2 emission levels to within prescribed standards when burning this coal.

Uranium - Analysis of recently published reports[b] on projected U.S. demand and reserves that are now reasonably assured indicates that

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b. Nuclear Industry Fuel Supply Survey, WASH-1196, U.S. AEC, April 1972; and The Uranium Supply Outlook, Short Term and Long Range, S. M. Stoller Corporation, J. F. Hogerton and C. E. Guthrie, September 1972.

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the reserves recoverable at $8 per pound "forward cost" will be depleted in the early 1980's.

In a later report,[c] the AEC estimates the U.S. uranium resources as shown in the table below.

Cost Cutoff $/Lb. U_3O_8	Tons U_3O_8 Reserves	Estimated Additional (Potential)	Total
$ 8	273,000	450,000	723,000
$15	520,000	1,000,000	1,520,000

The report indicates that the annual production rate from presently estimated $8 resources could be increased to about the level of demand projected for 1979. Subsequent needs might be met from known resources for a few years, but then, new low-cost resources would be required or higher-cost resources could be exploited if available. Doubtless, a large expansion of uranium exploration and production facilities will be needed.

It is believed by TVA and its consultants that the key to the supply outlook is the development of new reserves rapid enough to keep pace with projected requirements. Both the short-term and long-term uranium supplies are closely related to the establishment of acceptable market prices in the 1980's, and the known reserve levels will be expanded by further exploration effort.

9.2.0.3 Economic Comparison of Base-Load Alternatives - One of the major factors considered in the feasibility study of the alternative

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c. Nuclear Fuel Supply, WASH-1242, U.S. AEC, May 1973.

generating facilities is their comparative economics. Table 9.2-1 shows comparative investment costs, fuel costs, and operating and maintenance costs for the base-load alternative types of generating facilities studied during the 1980-82 period.

The investment costs are in terms of cost expected in the 1980-82 period. Substantially larger furnace volumes and more pulverizer capacity are required to burn low-sulfur coal, and the plant investment cost for low-sulfur coal reflects these requirements.

The indicated fossil fuel costs reflect the best judgment of today's market for these fuels. There are means of mitigating the cost associated with transporting low-sulfur coal, such as use of a coal slurry pipeline. Since this method of transporting coal is only in the preliminary stages, it has not been reflected in low-sulfur coal costs. Based on the recent bids for low-sulfur coal and discussions with coal suppliers, the reduction in the cost of transportation is not sufficient to result in the coal cost of this alternative being reduced below the breakeven fuel cost of approximately 30 cents per million Btu.

The comparison shows that the base-load nuclear plant offers a 3.1 mill per kWh economic advantage over the low-sulfur coal-fired plant, which is the next lowest cost alternative. This represents an annual production cost advantage for the nuclear plant of about $55 million for a 2,500-megawatt plant.

From the standpoint of economics, it has been concluded that nuclear capacity is the most attractive alternative type of feasible base-loaded capacity.

9.2.0.4 Potential Environmental Impact Comparison of Base-Load Alternatives - Table 9.2-2 summarizes, and quantifies to the extent practicable, the potential environmental impacts associated with the base-load alternative types of generating capacity.

In order to maintain a comparative perspective of the potential environmental impacts of each type, this table is based on a 1,200 megawatt installation.

Air Pollution - Degradation of the air quality because of fossil-fired power plant operation results principally from the emission of SO_2, NO_x, and particulates. The values shown for SO_2 emissions in table 9.2-2 assume that any new installation could meet the most restrictive SO_2 emission standard promulgated today. Thus all values shown are within permitted standards and are acceptable from the standpoint of protecting the public health and welfare. As previously discussed, the feasibility and justification of meeting such standards have not been demonstrated.

Even though low-sulfur coal does appear to be a possible alternative for meeting SO_2 emission standards, it is not clear that SO_2 removal equipment would not eventually be required to assure that TVA operates continuously within prescribed SO_2 emission standards. This, plus the economic penalties in plant costs and fuel costs, leads to the question of the acceptability and justification of this alternative as a means of meeting SO_2 standards.

The technology of removing sulfur dioxide from the exhaust gas stream of a power plant has not been demonstrated on a scale large enough to justify making long-range plans for the use of stack gas

scrubbers to control sulfur dioxide emissions. There are several competing processes[d] for removing sulfur dioxide from flue gas, none of which has yet operated for a sufficient time or on a sufficient scale to be called demonstrated technology. The outlook for the near future is not encouraging because of the inherent difficulty of extracting small concentrations of sulfur dioxide from very large volumes of gas. Furthermore, many of these processes produce substantial quantities of residual slurries that also pose significant environmental concerns.

The control of oxides of nitrogen is another area where the technology is very limited on units with coal firing. It appears that the best prospect for abatement of oxides of nitrogen is in the area of improved control of combustion temperature.

Air quality can also be significantly affected by moist plumes from large cooling towers, spray canals, or cooling ponds. The degree of impact from these sources varies with the type of cooling alternative used and local terrain characteristics.

NO_x emission levels vary considerably among the particular boiler designs. The emission levels shown are representative of today's boiler and gas turbine technology.

The particulate emission levels are based on the most restrictive standard proposed to date: 0.1 pounds of ash per million Btu input.

The only nonradiological atmospheric emissions associated with nuclear plants other than plumes from cooling towers, spray canals, or cooling ponds are small quantities of SO_2 and particulates from operation of auxiliary boilers and emergency diesels. These emissions are expected to be minimal. Atmospheric effects from cooling towers, spray canals,

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d. Paul W. Spaite, "SO_2 Control: Status, Cost, and Outlook," <u>Power Engineering</u>, October 1972, pp. 34-37.

or cooling lakes may be significant depending on site location and the type of cooling scheme used. The alternative type of generation with the least impact on air quality is nuclear.

Thermal Pollution - Table 9.2-2 indicates the heat rejected to the total environment--air and water--and that rejected to the condenser cooling water. This breakdown gives recognition to the fact that a portion of the heat rejected to the environment from fossil units is rejected directly to the atmosphere from the boiler, and consequently, its potential impact on the environment or cooling tower evaporation rate is less.

The high thermal efficiency of base-load coal-fired units (38 percent) results in approximately 50 percent of the heat input being rejected to the condenser cooling water. Intermediate-duty coal-fired units are characterized by a thermal efficiency of about 32 to 33 percent, which is approximately the same as that for light water reactors (LWR). Because of the heat rejected by stack gases, the heat rejection through the condenser is less than that in LWR's. Condenser heat rejection in LWR is about 40 to 50 percent more than for the coal-fired plant.

Radioactive Effluents - Based on TVA's analysis of previously committed light water reactors, the evaluation of the X17-X20 units, and analysis of the draft environmental statement on the 330-megawatt Fort St. Vrain high-temperature gas-cooled reactor being constructed by the Public Service Company of Colorado, both liquid and gaseous radioactive effluents from nuclear plants can be held to within the limits of proposed Appendix I to 10 CFR Part 50.

Coal contains small amounts of radium, uranium, and thorium, most of which remain in the fly ash or bottom ash after combustion.

Thus, in terms of "total curies" sizable amounts of natural radioactivity are discharged from fossil-fired power plants. Because of the physical form of this natural radioactivity (bound in fly ash or clinkers) and its low specific activity, there is thought to be almost no health hazard potential from this material.

Impacts Associated With Fuel - Table 9.2-2 indicates the estimated annual fuel consumption rates of each alternative for a 1,200-megawatt installation. The indicated rates result in significant differences in terms of the quantity of fuel required for mining and transportation.

Due to the nature of the formation of uranium deposits, significant quantities of uranium are usually found in concentrated deposits involving relatively small areas of land. The current U.S. industry average[e] requires that approximately one ton of uranium ore be mined and milled in order to produce about 4 pounds of U_3O_8. The current industry split[f] between the two methods of mining is 55 percent underground mining and 45 percent open-pit mining. A 1,200-megawatt nuclear installation requires about 200 tons of U_3O_8 per year. Therefore, based on the current industry averages, approximately 100,000 tons of uranium ore would have to be mined and milled.

The transport of fabricated fuel containing slightly enriched uranium to a plant site involves only minimal impact. A 1,200-megawatt unit would require only 5-10 truck shipments per year.

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[e] Fuel Trac Quarterly Report, April 1972, page I-1.

[f] Statistical Data of the Uranium Industry, U.S. AEC, Grand Junction Office, January 1, 1972, p. 32.

A base-load 1,200-megawatt coal-fired plant would require that 3.5 million tons of coal be mined and transported to the plant site. Based on current industry averages,[g] about one-half of this coal would be strip-mined and the remaining one-half would be mined in underground mines.

Transport of this coal would require that approximately 35,000 100-ton railcars be moved in and out of the plant each year.

While the overall impact of each alternative type of generation on fuel mining and transportation differs, the environmental impact of each alternative can be mitigated with proper reclamation practices. In the case of uranium mining, open-pit mining poses the more serious environmental impact; however, because of the relatively small concentrated areas in which uranium ore is found, its impact is limited.

TVA's final environmental statement, "Policies Relating to Sources of Coal Used by the Tennessee Valley Authority for Electric Power Generation," discussed the environmental impact associated with the mining of coal and described the policies and efforts of TVA to minimize these impacts. In particular, TVA's surface mining policies are designed to utilize a finite resource while at the same time making sure that the long-term productivity of the land will generally be equal to or greater than its premining productivity.

From the standpoint of the impact on transportation of fuel, the quantities associated with a nuclear plant are orders of magnitude less than fossil-fueled plants. However, the scale of a

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[g] Mineral Industry Survey, U.S. Department of the Interior, Bureau of Mines, September 11, 1972, p. 11.

material-handling operation is not judged to be a major overriding consideration since in most cases the transport of such material would utilize existing rail, highway, or waterway facilities.

Waste Disposal - Offsite disposal would be required for radioactive material. A 1,200-megawatt plant would require 5 to 10 rail shipments per year of spent fuel to reprocessing plants. Approximately 30,000 kilograms of fissile material--depleted uranium and plutonium--would be recovered from the spent fuel with a portion of the remaining fission products requiring permanent disposal by the fuel reprocessor. For other plant-associated low-level radioactive wastes such as demineralizer resins, evaporator bottoms, and debris, approximately 10 to 20 truck shipments per year would be required.

A 1,200-megawatt base-load coal plant would require a landfill area of sufficient size to dispose of approximately 1/2 million tons of ash per year. Over the life of the plant about 5,000 acre-feet of storage would be required for ash disposal. If SO_2 scrubbers are employed, special precaution would be required to assure that the resulting toxic residual does not escape from the storage area.

Land Use - The land required for a nuclear plant is principally a function of exclusion radius. The exclusion radius does not vary significantly between a 1-unit plant or a 4-unit plant. Consequently, assuming cooling towers are used for auxiliary cooling, the 800-1,000 acres indicated on table 9.2-2 would accommodate a 1,200-megawatt or 5,000-megawatt installation. The land requirements would be somewhat different if cooling ponds or spray canals were used. The configuration of land ownership and site characteristics could also increase land requirements above these figures for a particular selected site.

The area served by TVA has a relatively low population density. Because of this, TVA has flexibility in the siting of all generating plants so that the location of a generating facility can be selected to be compatible with its surroundings and existing land use. Nuclear plants are, in general, compatible with most existing land use and can be located in remote areas of the Tennessee Valley, if desired.

A 1,200-megawatt base-load coal-fired installation requires about 800-1,000 acres. Such an installation would generally be compatible with existing industrial land use.

Aesthetics - The most significant features of a nuclear installation are perhaps the visual impact from cooling towers and the resulting plumes, while for a coal-fired project, tall stacks, cooling towers and plumes, fuel storage facilities, and massive structures have a significant visual impact.

Noise - There are some noise levels associated with switch-yards that are generally common to each alternative, but in general, the size of the plant site reduces noise levels at site boundaries to acceptable levels.

For the coal-fired plant, a major source of offsite noise is the coal-handling equipment. Nuclear plants eliminate this source of noise.

9.2.0.5 Conclusion - The following conclusions form the basis for the recommendation of the preferred type of alternative generation for the 1980-82 period:

1. From the standpoint of fuel availability coal and nuclear fuels are available and involve significantly less risk of supply than oil-fired plants. The uncertainty of a reliable source of oil precludes serious consideration of an oil-fired unit at this time. There is no evidence to indicate natural gas will be permitted for base-load power generation, and consequently it is not considered as a viable alternative.
2. At this time, the most feasible method of providing base-load coal-fired capacity while meeting SO_2 emission standards based on today's technology and fuel availability appears to be by the use of low-sulfur coal.
3. System needs dictate the need for base-load capacity additions.
4. A nuclear plant has an annual economic advantage of approximately $55 million over a low-sulfur coal-fired alternative based on a 2,500-megawatt installation.
5. The potential environmental impacts of nuclear plants are considered to be less than other base-load capacity because (1) nuclear plants have no significant SO_2, NO_x, or particulate emissions; (2) nuclear plants require less land than comparably sized base-load fossil plants; (3) nuclear capacity involves less of an environmental impact from mining and transportation because of smaller quantities and the concentration of uranium deposits; (4) nuclear units produce a substantially smaller volume of waste material requiring disposal than fossil even

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though care must be exercised in the handling and disposal of nuclear wastes; and (5) a nuclear plant results in cleaner, quieter, more aesthetically pleasing power plant installation.

The radioactive releases from a nuclear power plant during normal operation can be held well within applicable standards with the application of current technology. Consequently, these releases are considered to be an insignificant environmental factor in the comparisons of alternatives.

Thus, from the overall consideration of feasibility, cost, and potential environmental impact, nuclear plants are judged to provide the preferred type of base-load capacity addition now available to meet TVA's power supply requirements for the 1980-82 period.

9.2.1 Selection of Candidate Areas - The TVA Act requires that an ample amount of low-cost electricity be provided throughout the area in which TVA conducts its operations. This responsibility requires the need for ongoing studies covering all aspects of the TVA power program. As an integral part of this program, studies of sites suitable for location of generating facilities is essential. In order to meet the peak load periods projected, TVA will have to increase its generating capacity a substantial amount in the foreseeable future. This large-scale growth requirement will demand the identification of many suitable sites. In planning ahead to meet future load growth, the selection of the preferred site for a particular facility involves the best balance of the engineering, economic, and environmental factors related to the sequence of TVA's power system development. Numerous candidate sites will continue to be considered in subsequent siting studies as appropriate as part of the continuing process to determine the best location for adding electrical generating plants to the TVA power system.

Since the late 1940's, TVA has conducted studies of suitable sites for new power facilities. Through the years, siting requirements and considerations have evolved to meet changing technology. Throughout the 1950's, most of TVA's capacity additions were 125- to 275-megawatt coal-fired generating units whose principal siting constraints relate to the environmental effects of emissions and the economic factors associated with the balance between the construction of transmission lines and the costs of transporting coal to the site. The size of TVA's system, plus the technological advances of the electrical manufacturing industry, enabled TVA to install successively larger coal-fired units, thereby realizing the economics of larger units. Siting considerations for these larger units were essentially the same as for smaller units.

The TVA siting procedure is designed to meet its responsibilities to provide an ample supply of electrical energy throughout the region. Studies are initiated on a timely basis to:

1. Identify the portion of the system in which a particular capacity addition is most desirable. These studies are based primarily on projected load and supply requirements of various regions and include an assessment of the transmission flexibility. The results of these studies indicate the priorities to follow in further investigations.
2. Identify and investigate feasible sites in the areas of study based on the priorities established in (1) above. The establishment of priorities takes into account the total power program and considers requirements of previously committed capacity and the constantly changing lead-time requirements that are now evolving.
3. Perform detailed site studies and gather onsite data for possible candidate sites on a schedule consistent with the requirements of the capacity addition being considered.
4. Evaluate candidate sites and select the preferred site based on the investigations performed in (3) above on a time schedule consistent with the inservice dates of the specific capacity addition under study.

Historically TVA's siting studies have been conducted to meet the requirements of the type of capacity being considered for installation. With the selection and addition of nuclear capacity these investigations have become more intensive to meet the stringent engineering requirements of nuclear power plants and the associated environmental considerations.

The TVA site screening process identifies the more favorable sites after considering such factors as access, proximity to transmission interconnections, flooding conditions, topography, seismology, and potential environmental impacts. The more favorable sites are pursued taking into account priorities set from regional load and supply factors, long-range transmission planning, and the allocation of available resources. In this manner the expensive and time-consuming process of gathering sufficient detailed site-related data to ascertain site feasibility is kept abreast of current needs.

The TVA power system is a winter and summer peaking system with the highest annual peak loads in the TVA service area usually occurring between November and March. Historically, about 25 to 30 percent of TVA's total peak requirements have been concentrated around the major load centers of Nashville, Memphis, Knoxville, Huntsville, and Chattanooga. In addition, the AEC requirements at Paducah and Oak Ridge have contributed significantly to TVA's peak demands. The TVA system has numerous interconnections with other systems and exchanges seasonal capacity with three interconnected systems.

The vast majority of seasonal exchange is in the western part of the TVA system and acts as a load center during the summer months when TVA supplies power and as a generation source in the winter months when TVA receives power. With the widely dispersed load centers within TVA and the seasonal exchange requirements with systems having summer peaks, TVA's transmission system network is by necessity extensive, and its future development is affected by the location of generating sources.

An essential part of TVA's siting process is designed to minimize this heavy investment by locating generating facilities in those areas of the system where forecasted demands require additional generating capability. This avoids the necessity of constructing long transmission lines from areas of surplus generation to serve the load centers of other areas, thus reducing transmission investment, associated losses, and environmental impacts associated with transmission lines. In some parts of the country the relationship between load and supply has become less important with the advent of EHV transmission; however, because of the size of the TVA service area and the large investments involved, the geographic relation of generation to load has been and continues to be an important siting consideration and is a principal factor used to establish area investigative priorities.

In order to study load growth and the general power flows in the system and to determine the effects of the specific location of power generation sources, the TVA power system has been divided into five study areas. These areas as shown in Figure 9.2-1 coincide roughly with the five TVA Power Marketing districts (Western, Central, Eastern, Alabama, and Mississippi) and divide the system according to the concentration of load centers (Memphis; Nashville; Knoxville; Chattanooga and Huntsville; and Muscle Shoals and Mississippi). While these areas are shown individually, the system is not in fact divided since these areas are strongly interconnected with transmission lines.

Figures 9.2-2 and 9.2-3 are graphical representations of the winter and summer load and supply analysis of these areas. They present the projected peak requirements (load and reserves) and TVA's capability of supplying these loads based on the total committed

generating capability installed prior to the Hartsville plant, including the effects of existing interchange agreements. As indicated, the load growth in areas 1, 2, and 5 (Western, Central, and Mississippi areas, respectively) are roughly comparable with system trends, but with no scheduled additions in generating capability through 1979, the new demands could exceed the areas' generating resources.

This trend is most accentuated in area 2 where the deficits in generating capabilities exceed 4,500 megawatts by the winter peak of 1981 and approximately 6,000 megawatts by 1985. Areas 1 and 5 which have large seasonal swings are in basically the same situation as area 2 but to a lesser degree. Areas 3 and 4 (Eastern and Alabama areas) have capability resources in excess of projected demands with one exception--analysis of areas for winter 1985 shows a deficit of approximately 600 megawatts. Therefore, from area load and supply analysis, area 2 was a principal candidate area for future generating resources during the 1980-82 period.

Although meeting the projected area 2 load requirement is of first priority, the needs of areas 1 and 5 cannot be overlooked. During the 1980-82 period these areas will demand sizable amounts of energy to meet interchange commitments and seasonal requirements. Although transmission proximity is an important consideration studies cannot be solely established on the basis of one area's requirement but must be examined from the standpoint of system stability and reliability. Therefore, two basic considerations in site location studies are:

1. Proximity to projected high load growth areas, and
2. System transmission stability and reliability associated with requirements existing and projected

Based on the load and supply situation and the seasonal exchange requirements, areas 1, 2, and 5 were judged to represent the more desirable area locations - areas 1 and 5 due to seasonal exchange requirements and area 2 based on generation deficits.

9.2.1.1 Areas 1 and 5 - These areas exhibited significant deficiencies in the 1980-82 study period, but to a lesser extent than the area 2 requirements. However, much of the western portion of the area served by TVA (areas 1 and 5) is included in an area in which the seismic conditions are not clearly defined. This area is in close proximity to an area in which major seismic activity has occurred as recently as the early 1800's. This area has been under study by TVA and its consultants to define the seismic conditions in the area. A report entitled Relationship of Earthquakes and Geology in the West Tennessee and Adjacent Areas was submitted in June 1972 to AEC's Director of Regulation for consideration in determining the seismic design criteria for this area.

In November 1973 letter to the Chairman of the U.S. Atomic Energy Commission the Advisory Committee on Reactor Safeguards (ACRS) stated their belief that the intensities proposed by TVA and its consultants appear to be reasonable for the section of the western portion of the TVA service area in question and should provide a satisfactory basis for the development of seismic design parameters for specific sites in the area. Consequently, while the specific seismic design parameters for sites in the western portion of the area served by TVA are still not defined, the basis for their definition appears to be acceptable to the AEC.

However, with the award of the nuclear steam supply system contract in December 1972 the design of this plant had progressed to the point that to revert to a site in the western portion of the TVA system without clearly defined seismic parameters would result in significant plant delays.

In fact, by November 1973 TVA had made a major commitment to standardize the design of this project. After several months of discussions, TVA issued a letter of intent to the General Electric Company for a contract to design six buildings of this plant in accordance with General Electric's standard safety analysis report which was docketed by the AEC. This approach is consistent with the announced standardization policy of the AEC for improvement in the overall licensing process and schedules on nuclear plants. To revert to a site in an area where the seismic criteria is undefined would likely be inconsistent with the standardized plant approach. This would be contrary to the standardized approach and could seriously delay, not only the design of the project, but the licensing activities of this project. The total impact on the project schedule is judged by TVA to be intolerable and extremely costly.

As a result, areas 1 and 5 are not the preferred area to locate this generating project.

<u>**9.2.1.2 Area 2**</u> - The previously discussed load and supply analysis indicated this area as developing the primary needs for generating resources during the 1980-82 time period. This, in combination with its known seismic requirements made area 2 the primary area of concentrated study for the preferred location. Figure 9.2-4 shows the area roughly defined as area 2 and the sites identified in the area.

9.2.2 Selection of Candidate Sites - Since 1970 studies have been conducted in area 2 with a total of 48 sites being identified through FY 1972 (see Figure 9.2-4). In July 1972 TVA concluded the first phase of investigations in area 2. These studies were based on each site's conformity to the stringent requirements for present-day generating plants. Included in the preliminary screening processes were the following:

1. Map reconnaissance, aerial survey, and field reconnaissance
2. Land use and ownership assessment
3. Proximity to existing transmission lines
4. Site access - rail, highway, barge
5. Proximity to population centers
6. Seismology
7. Availability of cooling and/or makeup water and water use compatibility
8. Topography of the site
9. Flooding conditions
10. Foundation conditions
11. Proximity to significant recreational, wildlife, or cultural areas

On more detailed study it became apparent that some of the 48 sites were not economically suitable for the development of a nuclear plant due to such factors as low plant grade, land use conflicts, and inadequate foundation conditions. Four sites were found to meet the requirements of a 4-unit nuclear plant and were judged to be superior to other candidate sites after considering the above factors. These were the Antioch and Hartsville sites on the Cumberland River and the Council Bend and Rieves Bend sites located on the Duck River.

The general location of these sites is shown on Figure 9.2-5.

The discussion of the four candidate sites is limited in scope to the principal factors related to the selection of the preferred site. The information reported in this section corresponds to the information and data which was available at the time TVA evaluated the candidate sites and selected the Hartsville site as the preferred site. Therefore, the Hartsville site characteristics presented in this comparison may differ from information described in other sections of the environmental statement which was obtained as a result of the more intensive Hartsville site investigations performed after Hartsville was selected as the preferred site. To date these more intensive studies of the Hartsville site have not revealed any significant changes in site characteristic or previously undetected factors which would alter the selection of the Hartsville site as the preferred site.

9.2.2.1 Site Descriptions - Antioch site is located on the north shore of the Old Hickory Reservoir at Cumberland River Mile 259 in Sumner and Trousdale Counties, Tennessee, approximately 6.5 miles southwest of Hartsville, Tennessee (see Figure 9.2-6). The site would consist of approximately 950 acres of moderately rolling terrain, most of which is densely wooded. Ground surface elevations range from 445 along the reservoir to over 600 feet above mean sea level at a hilltop near the western boundary of the site.

An aerial photograph of this site indicating the basic 4-unit plant outline is shown in Figure 9.2-7. Highway access to the site would require less than 1 mile of new road from U.S. 231. Railroad access

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would be provided with the addition of 8.6 miles of connector track to the L&N Railroad, north of the site. The Cumberland River is navigable from its mouth to the site, and therefore barge facilities are feasible at this site. The smallest downstream lock is at the Old Hickory Dam (84 feet by 400 feet).

The Hartsville site is located on the north shore of the Old Hickory Reservoir at Cumberland River Mile 285, in Smith and Trousdale Counties, Tennessee, approximately 5 miles southeast of Hartsville Tennessee (see Figure 9.2-8). The site would consist of approximately 1,400 acres of rolling terrain with surface elevations ranging from 460 to 560 feet above mean sea level. An aerial photograph of this site indicating the basic four-unit plant outline is shown in Figure 9.2-9. Highway access would require rebuilding about 0.5 mile of existing secondary road to connect the site with Tennessee State Highway 25 located north of the site. Rail access would require approximately 6.4 miles of new track to connect the site with the L&N Railroad near Hartsville, Tennessee. Barge facilities are feasible at this site.

Council Bend site is located on the left bank of the Duck River at river mile 60 in Hickman County, Tennessee, approximately 4 miles north-east of Centerville, Tennessee (see Figure 9.2-10). The site would consist of approximately 1,400 acres of farmland, which is now used mostly for pasture; ground surface elevations vary from approximately 460 along the river to over 540 feet above mean sea level at the high ground immediately inland from the plant site. An aerial photograph of this site indicating the basic four-unit plant outline is shown in Figure 9.2-11. Highway access to the site would require approximately 2 miles of new road extending from Tennessee State Highway 50. Rail access would require a bridge to be

constructed across the river to connect with the L&N Railroad about 3 miles east of the site. Barge facilities are not feasible at this site due to the nonnavigability of the Duck River.

Rieves Bend site is located on the south shore of the proposed Columbia Reservoir at Duck River Mile 146 in Maury County, Tennessee, about 3 miles southeast of Columbia, Tennessee (see Figure 9.2-12). The site would consist of approximately 1,500 acres with ground surface elevations varying from 630 to 740 feet above mean sea level. An aerial photograph of this site indicating the basic four-unit plant outline is shown in Figure 9.2-13. Highway access for this site would require about 2.5 miles of new road to connect the site with Tennessee State Highway 50 which connects with I-65. Rail access would require 2.5 miles of new track and the crossing of two embayments of the Columbia Reservoir to connect the site with the L&N Railroad. Barge facilities are not feasible at this site due to the nonnavigability of the Duck River.

Detailed investigations of these four sites were designed to cover the major site evaluation factors grouped in three basic categories--transmission requirements, engineering feasibility, and environmental impacts. Transmission requirements and engineering feasibility are discussed in Sections 9.2.2.2 and 9.2.2.3. Environmental impacts are discussed in Section 9.3.1.

9.2.2.2 Transmission Requirements - Estimates were prepared for the transmission line interconnections necessary to connect the plant to the TVA transmission system network that would exist in the 1980-82 period at each of the four alternate sites. These estimates were made to determine the number of transmission connections and the general route of each. A more detailed survey and analysis would be

required to determine the best alternative route for each line. Consequently, these estimates were more indicative of the system electrical requirements and reflect the comparative differences between sites rather than the ultimate choice of transmission line routing for a particular site.

System network studies indicated that at least six 500-kV transmission lines will be required to connect the 4-unit plant into the system for plant stability, reliability, and for proper distribution of the generation to the load centers in the area. In addition to these direct connections, the location of large blocks of generation also influences the transmission requirements in other portions of the system to provide the ability to transport power from one portion of the system to another during seasonal changes in power flow and during periods of system emergencies. This is reflected in the following comparative tables, schematics, and discussions of the transmission connections required for each site. The acreage associated with the required rights of way is discussed under Land and Land Use.

Figure 9.2-14 shows the base transmission network configuration as projected for the 1980-82 period into which the plant would be connected. Proposed requirements for each site are as follows.

Antioch - Figure 9.2-15 shows schematically, the connections required to the base system if the plant was located at the Antioch site. About 377 miles of 500-kV lines and 8 miles of 161-kV lines will be required for this site. Six 500-kV transmission lines are proposed as follows.

1&2.	Bull Run - Wilson 500-kV loop single circuit -	36 miles
3.	Wilson 500-kV substation connection -	16 miles
4.	Montgomery 500-kV substation connection -	65 miles
5.	Two lines for Maury 500-kV substation connection -	70 miles
6.	Two lines for Maury 500-kV substation connection -	75 miles
	Total 500-kV connections	262 miles
	Browns Ferry-Union substation connection	115 miles
	Total 500-kV requirements	377 miles

<u>Hartsville</u> - The transmission connections to the Hartsville site shown in Figure 9.2-16 would be basically the same as those for Antioch, except that the transmission line mileages are slightly greater. The transmission lines and mileages are as follows.

1&2.	Gallatin Steam Plant-Cordell Hull 161-kV loop single circuit -	8 miles
3.	Bull Run-Wilson 500-kV loop single circuit -	34 miles
4.	Wilson 500-kV line No. 2 -	24 miles
5.	Montgomery 500-kV line -	72 miles
6.	Maury 500-kV line No. 1 -	75 miles
7.	Maury 500-kV line No. 2 -	77 miles
	Total 500-kV connections	282 miles
	Browns Ferry-Union substation connection	115 miles
	Total 500-kV requirements	397 miles

While these six 500-kV lines and the two 161-kV lines satisfy the direct connection criteria, a new 115-mile 500-kV line from the Browns Ferry Nuclear Plant to the proposed Union Substation will be required. This line results from transmission system studies which show the need for an additional high-voltage transmission connection to the western part of the system during the 1980's when large blocks of generation are installed in the eastern or central parts of the system. While this line is not directly required for connecting plants located at the Antioch or Hartsville sites to the system, it is shown as part of the system connections in order to provide an equitable comparison with the plant locations at the Council Bend and Rieves Bend sites.

Council Bend - Figure 9.2-17 shows the proposed connections if the plant was located at Council Bend. About 266 miles of 500-kV lines and 3 miles of 161-kV lines would be required at this site. Six 500-kV lines are proposed as follows.

1&2.	Maury-Cordova 500-kV loop double circuit -	23 miles
3&4.	Davidson-Johnsonville 500-kV loop double circuit -	18 miles
5.	Jackson substation connection -	80 miles
6.	Shelby 500-kV connection -	145 miles
	Total 500-kV connections	266 miles
	Johnsonville-Mount Pleasant to Council Bend single circuit -	3 miles

<u>Rieves Bend</u> - At the present time, there are plans to construct a 500-kV substation in Maury County a few miles north of Columbia, Tennessee--about 10 miles northwest of the Rieves Bend site. These plans include the following transmission system additions.

1. Loop the Browns Ferry-Davidson 500-kV line into the Maury Substation.
2. Construct a 500-kV line to the proposed Franklin, Tennessee, Substation.
3. Construct a 500-kV line to the Cordova Substation (Memphis area).
4. Provide 500-161-kV stepdown facilities for the Columbia area.

If the Rieves Bend site were selected as the preferred location the Maury Substation would not be built; however, the facilities planned for Maury would be relocated near the Rieves Bend site. The transmission facilities for the Rieves Bend site, as shown schematically in Figure 9.2-18 are as follows.

1. Loop the Browns Ferry-Davidson 500-kV line into Rieves Bend in lieu of Maury - 2 miles
2. Extend the Franklin 500-kV line into Rieves Bend instead of Maury single circuit - 7 miles
3. The Cordova 500-kV line planned out of Maury would be relocated and terminated at Rieves Bend. This would result in 7 fewer miles of 500-kV transmission line.
4. A new 115-mile 500-kV line to the proposed Jackson 500-kV substation would be constructed to serve the Jackson, Tennessee area loads - 115 miles
5. Construct a new 85-mile 500-kV line to the Wilson 500-kV substation - 85 miles

6. Construct a 170-mile 500-kV transmission line to the proposed Shelby 500-kV substation in the Memphis area. This line will satisfy the need for an additional high-voltage tie to the western part of the system and may be substituted for the proposed Browns Ferry-Union 500-kV line in the transmission plans for Antioch and Johntown - 170 miles

7. The 500-161-kV stepdown facilities originally planned for the Maury 500-kV substation would be provided at the Rieves Bend site and would serve as an offsite power source - 0 miles

Total 500-kV connections 379 miles

9.2.2.3 Engineering Feasibility - The engineering feasibility of a site for a nuclear plant is principally a function of three primary considerations.

1. Seismology
2. Geologic conditions
3. Flooding conditions

The following discussion summarizes the results of analyses performed on each site to determine its feasibility.

Seismology - Each of the four sites lies within the same tectonic province, the Nashville Dome. The design criteria for each site would be governed by a reoccurrence of a major earthquake in the Reelfoot Tectonic Structure west of the Nashville Dome. Analysis of a major earthquake reoccurring in the Reelfoot Tectonic Structure shows that the maximum intensity felt at the sites would be MM VII.

For design purposes it was assumed that the greatest acceleration affecting any of the sites would be the result of a major earthquake occurring on the eastern boundary of the Reelfoot Tectonic Structure. Based on the envelope of attenuation curves prepared during the western area earthquake study, the maximum intensity at any of the sites from a major quake on the Reelfoot Tectonic Structure would range from a high of MM VII to a low of MM III.

The maximum acceleration for intensities of this level was estimated to be 0.14 g. On this basis all of the four sites were judged suitable for meeting seismic design requirements of nuclear plants.

<u>Geologic Conditions</u> - From a geologic standpoint, all of the sites could probably be used; however, due to presence of pinnacled rock at Antioch and cavernous zones at Council Bend, an extensive grouting and excavation program would be necessary. An adequate foundation could be obtained at either Hartsville or Rieves Bend at a relatively low economic cost. Due to the presence of bentonite seams at Hartsville, the Rieves Bend site offers the best geologic structure for a nuclear plant foundation. Consequently, the order of geologic preference would be:

1. Rieves Bend
2. Hartsville
3. Antioch
4. Council Bend

<u>Flooding Conditions</u> - With the exception of Council Bend, all the site grades are sufficiently high to provide protection against flood. Because of the preliminary nature of the calculations, the adequacy of the Council Bend site was considered marginally acceptable.

From the standpoint of the engineering feasibility factors noted above, the order of site preference would be:

1. Rieves Bend
2. Hartsville
3. Antioch
4. Council Bend

Table 9.2-1

ECONOMIC COMPARISON OF BASE-LOAD ALTERNATIVE CAPACITY ADDITIONS

8% Interest

		Coal Fired	
	Nuclear	Low Sulfur	Medium Sulfur[b]
Installed Capacity - net MW	2,473.0	2,533.0	2,488.5
NPHR - Btu/kWh	9,927.0	9,070.0	9,036.0
Fuel Cost - ¢/10^6 Btu	20.0	60.0	45.0
Investment - $/kW (net)[a]	335.2	300.0	341.6
Annual Use - hours	7,000.0	7,000.0	7,000.0
Generating Cost - mills/kWh			
Investment	4.1	3.7	4.2
Fuel	2.0	5.4	4.1
O & M	0.7	0.8	2.0
Totals	6.8	9.9	10.3

[a] All capital cost estimates include cooling towers.

[b] Includes estimates of SO_2 removal equipment capital and operating costs.

Table 9.2-2

COMPARISON OF ENVIRONMENTAL IMPACTS OF BASE-LOAD ALTERNATIVE GENERATION FOR 1,200-MEGAWATT INSTALLATION

	Nuclear	Coal-Fired
1. Air Pollution - tons/yr.		
a. SO_2 emissions[a]	Negligible	42,800
b. NO_x emissions	Negligible	33,600
c. Particulate emissions[a]	Negligible	3,800
2. Heat Rejected - 10^9 Btu/h		
a. Total rejected	6.5-7.8	6.8
b. Total rejected to cooling water	6.5-7.8	5.7
3. Radioactive Effluents	Within Proposed Appendix I Limits	trace
4. Annual Fuel Consumption	200 tons U_3O_8	3,500,000 tons
5. Mining[b]	Underground - 55% Surface - 45%	Underground - 50% Surface - 50%
6. Annual Fuel Shipments		
a. New fuel	5-10 trucks	35,000 railcars
b. Spent fuel	5-10 rail shipments	-
7. Waste Disposal		
a. Ash disposal - thousand tons/yr	-	520
b. Radioactive wastes - truck shipments/yr	10-20	-
8. Land Requirements - acres	800-1,000[c]	800-1,000
9. Noise	Quiet Installation	Fuel-Handling Facilities Principal Source
10. Aesthetics	Predominant Feature is Cooling Towers, Large, but Relatively Low-Profile Plant Structure	Tall Stacks, Cooling Tower Structures, and Fuel Storage Facilities Dominate Installation

(See footnotes on following page)

Table 9.2-2 (continued)

COMPARISON OF ENVIRONMENTAL IMPACTS OF BASE-LOAD ALTERNATIVE GENERATION FOR 1,200-MEGAWATT INSTALLATION

[a]Assuming all applicable standards can be met on coal-fired.

[b]Based on the current trends of mining uranium and coal in the United States.

[c]Also adequate for 4,000-5,000 megawatt installation.

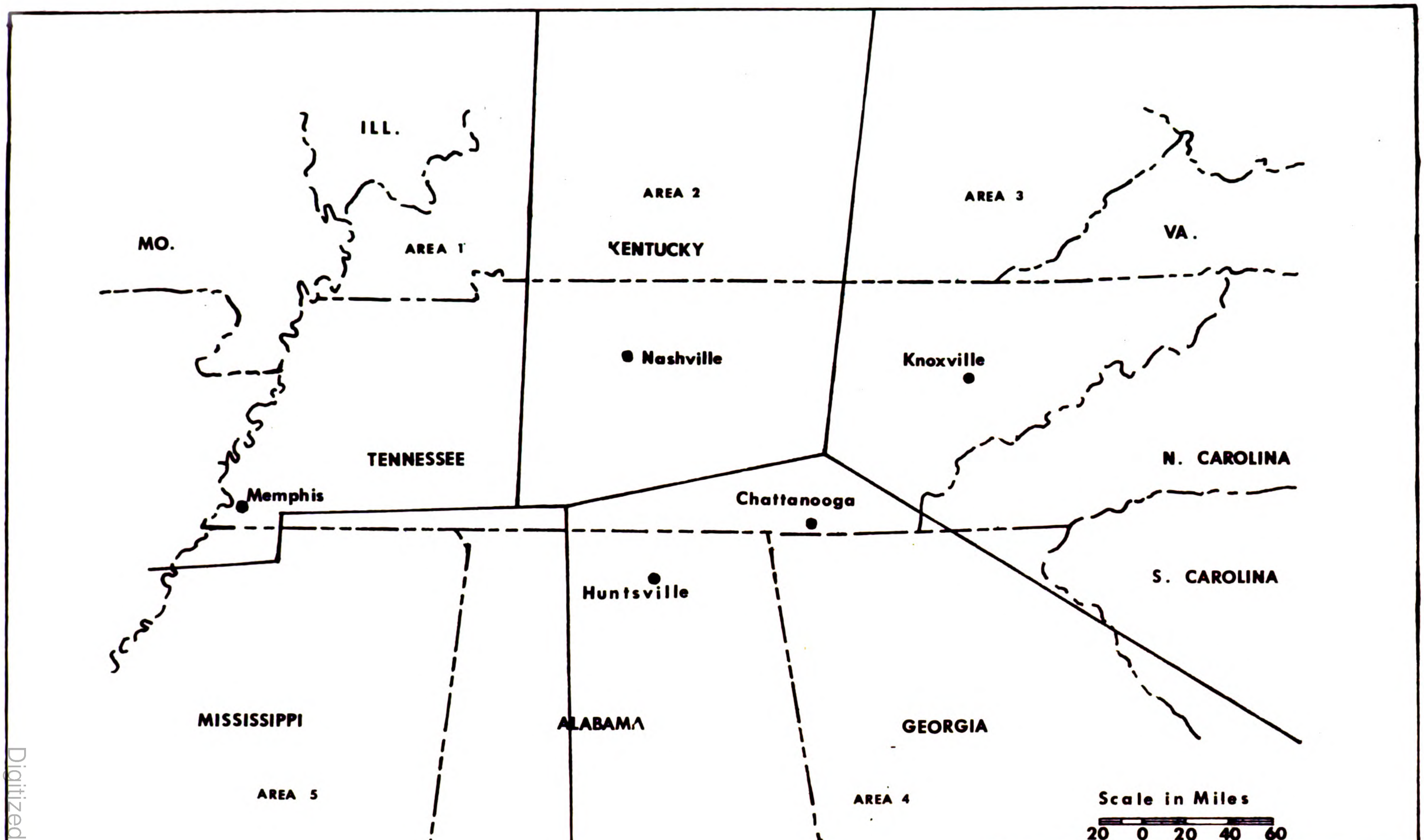


Figure 9.2-1

FIVE MAJOR TVA STUDY AREAS

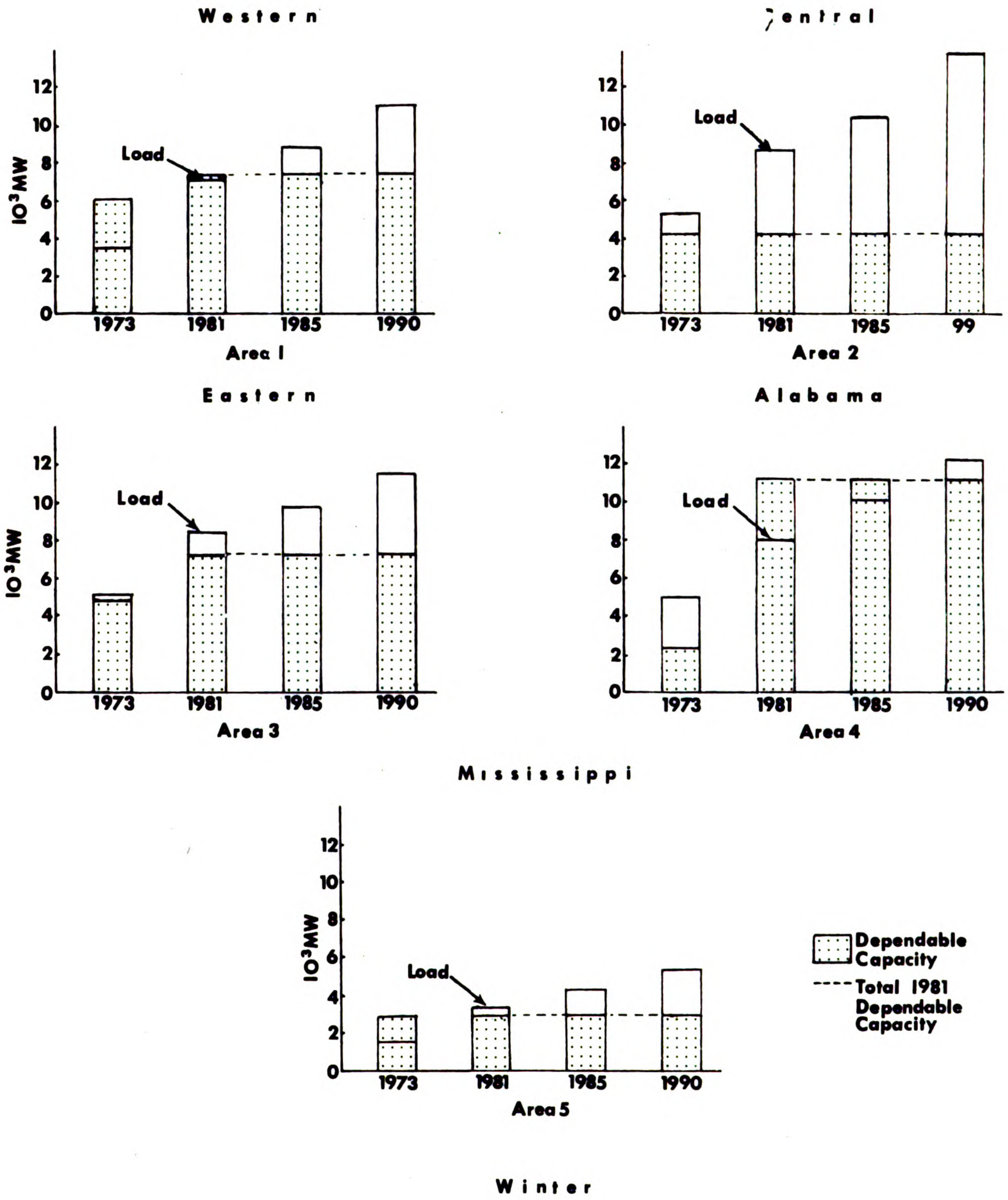


Figure 9.2-2

TVA LOAD AND SUPPLY ANALYSIS

WINTER PEAKS

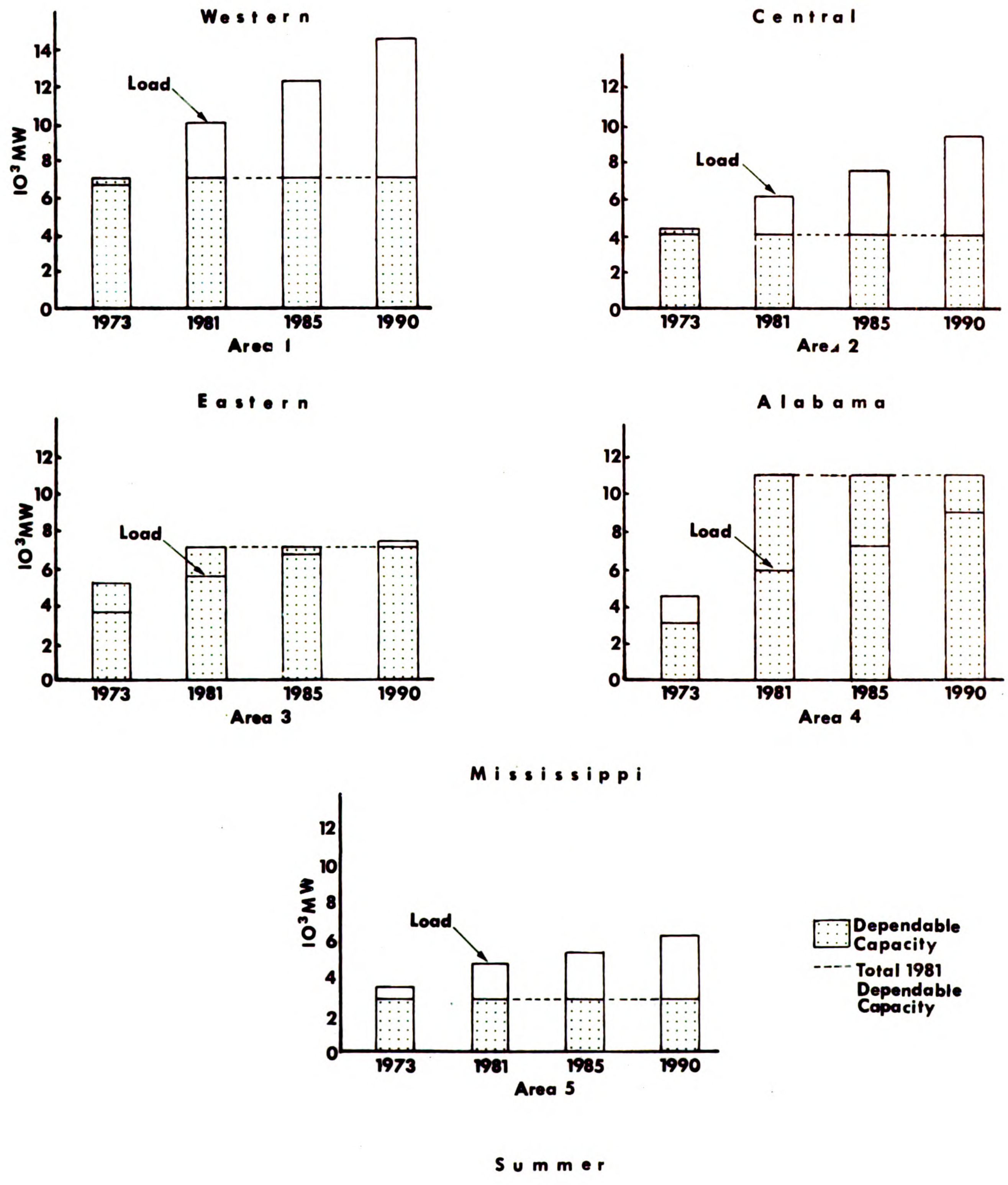


Figure 9.2-3

TVA LOAD AND SUPPLY ANALYSIS
SUMMER PEAKS

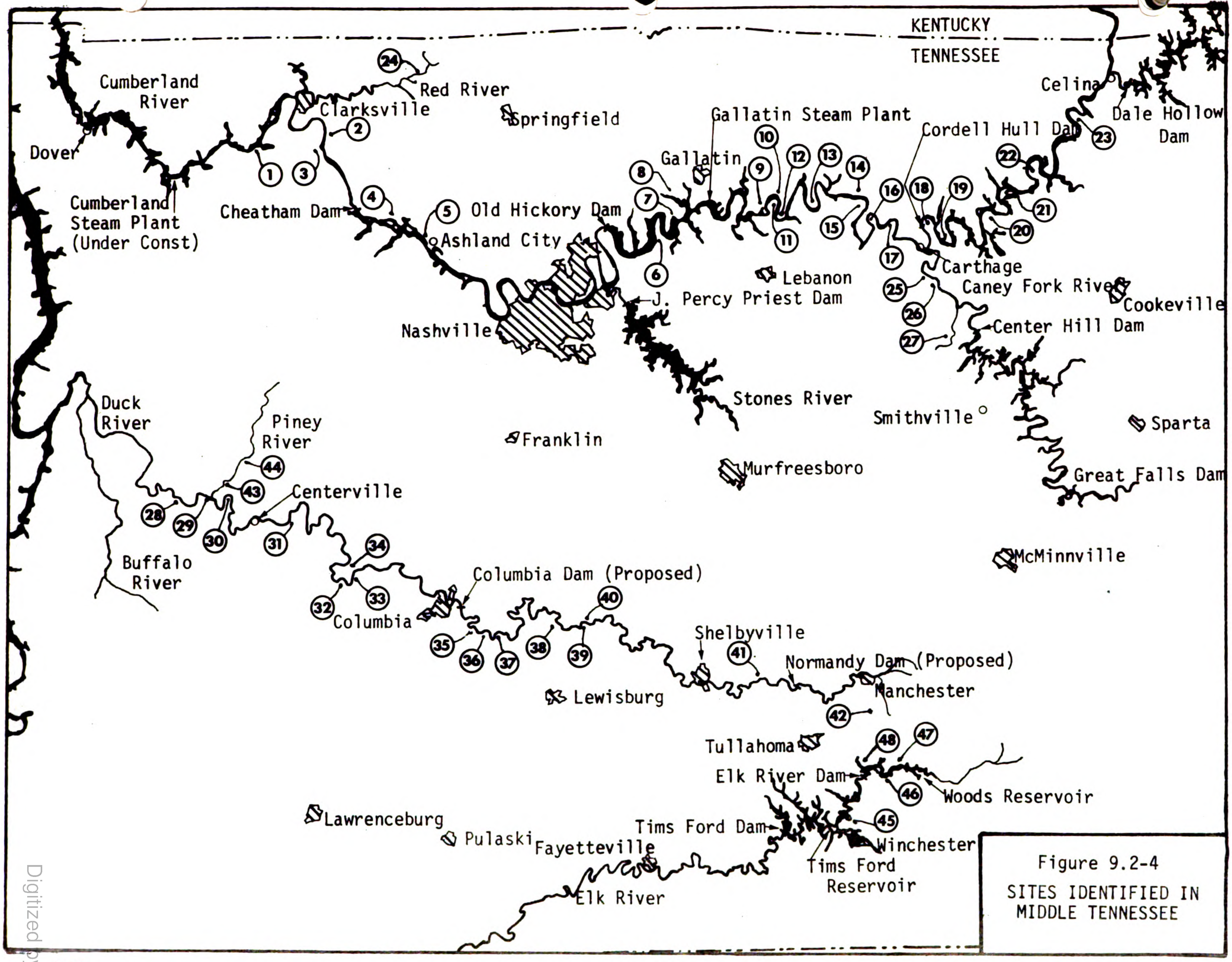


Figure 9.2-4
SITES IDENTIFIED IN MIDDLE TENNESSEE

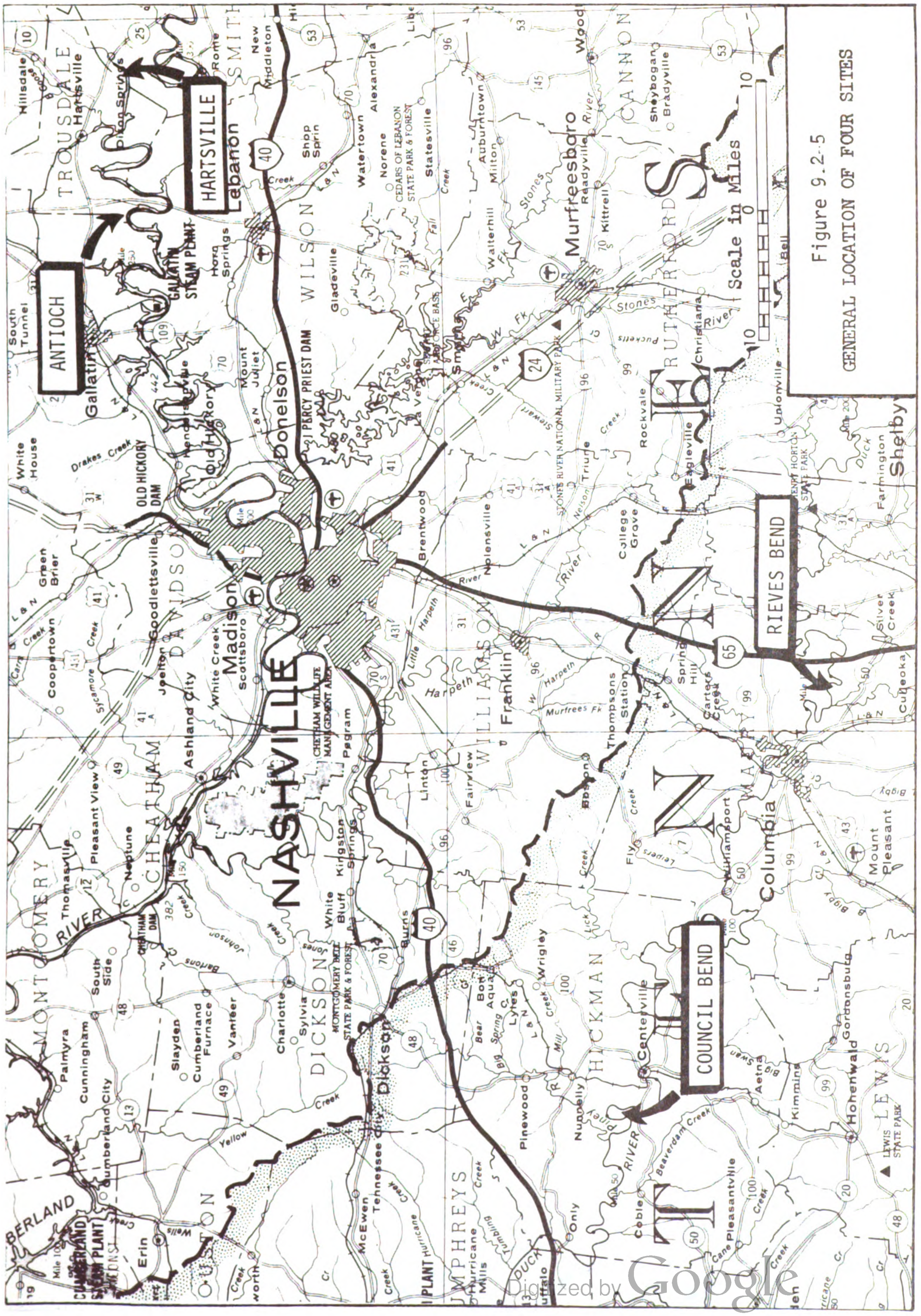


Figure 9.2-5
GENERAL LOCATION OF FOUR SITES

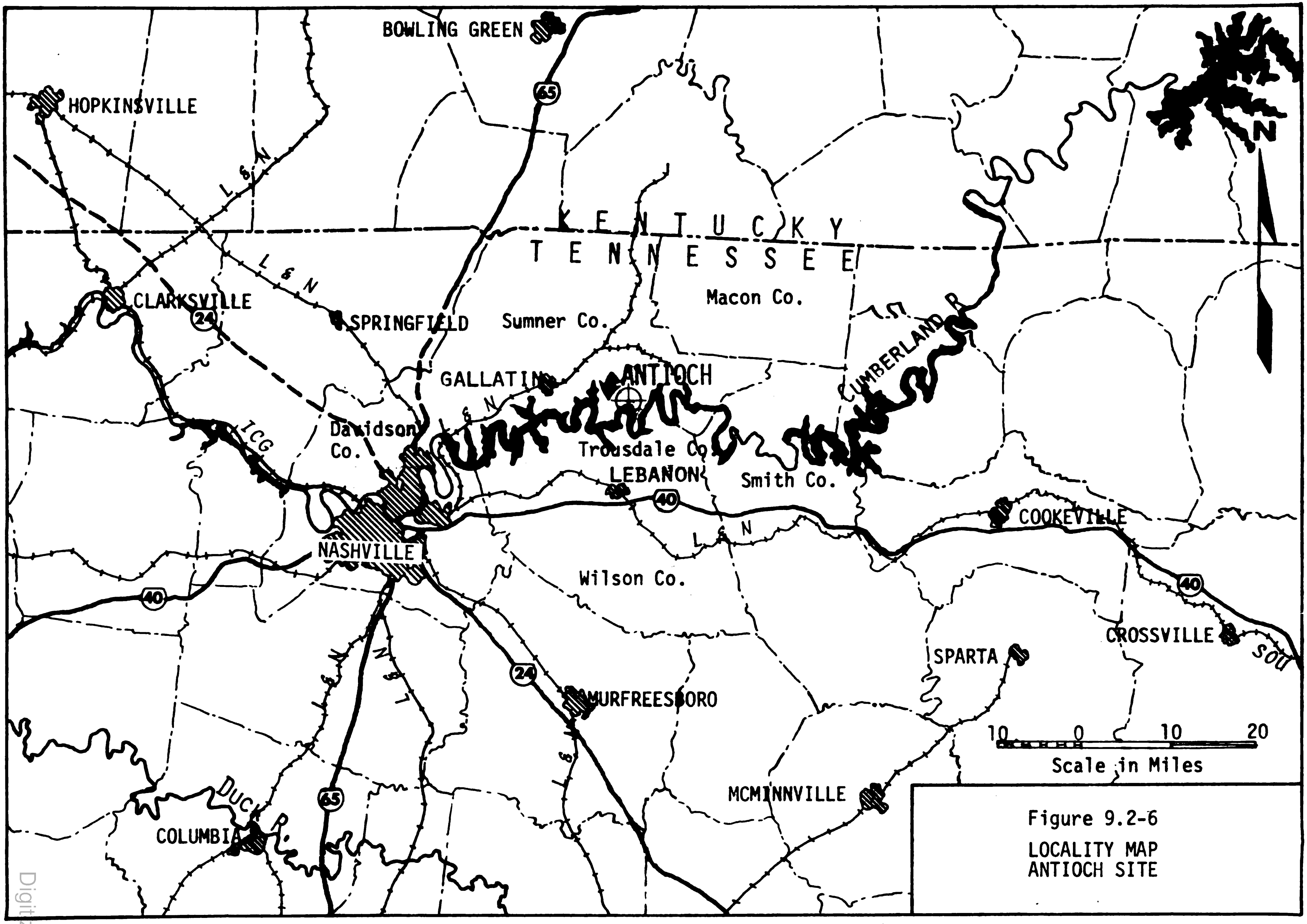
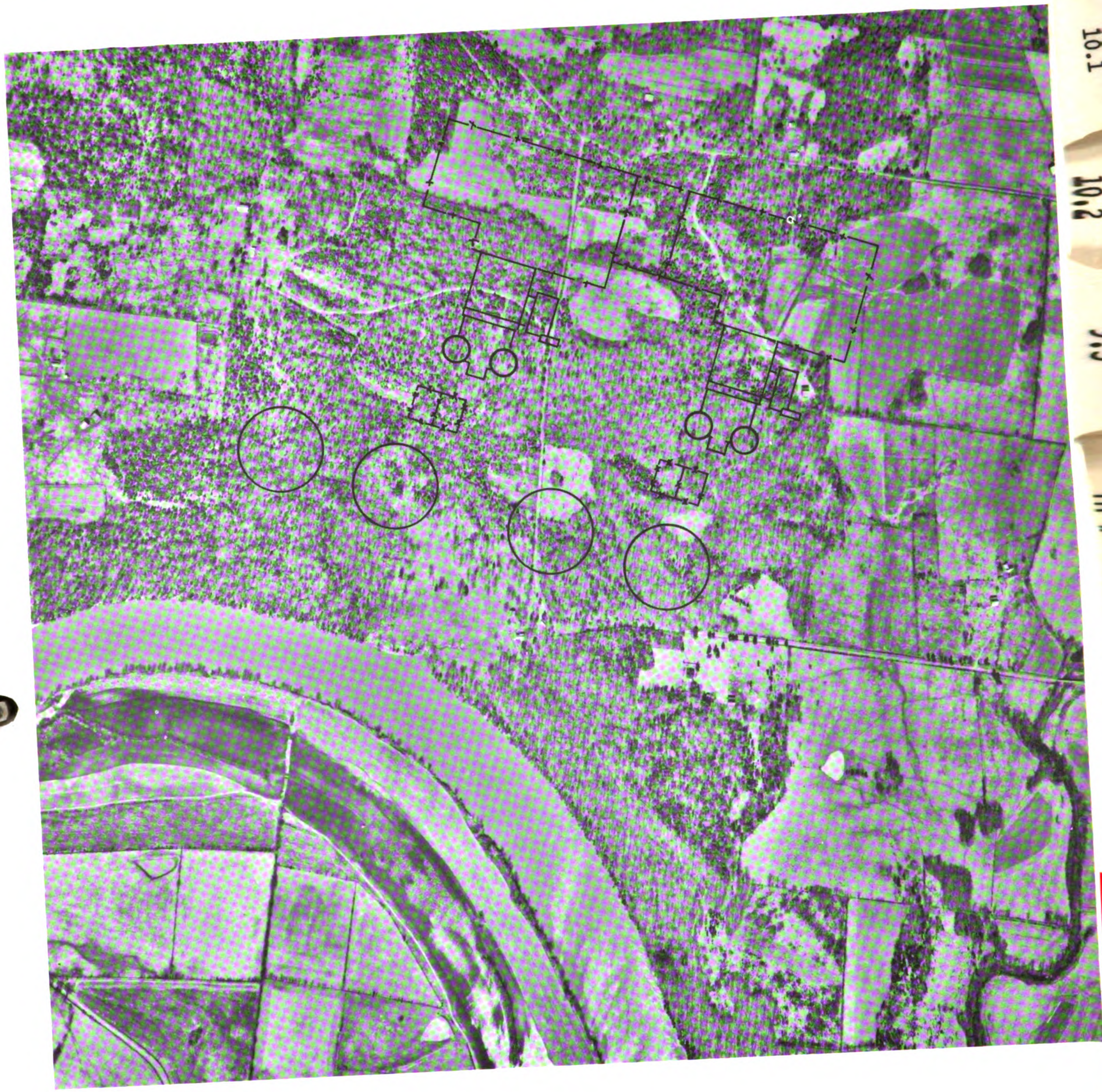


Figure 9.2-6
LOCALITY MAP
ANTIOCH SITE



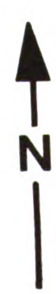


Figure 9.2-7

ANTIOCH PLANT SITE

Cumberland River Mile 259R

800' 0 800'

APPROX. SCALE

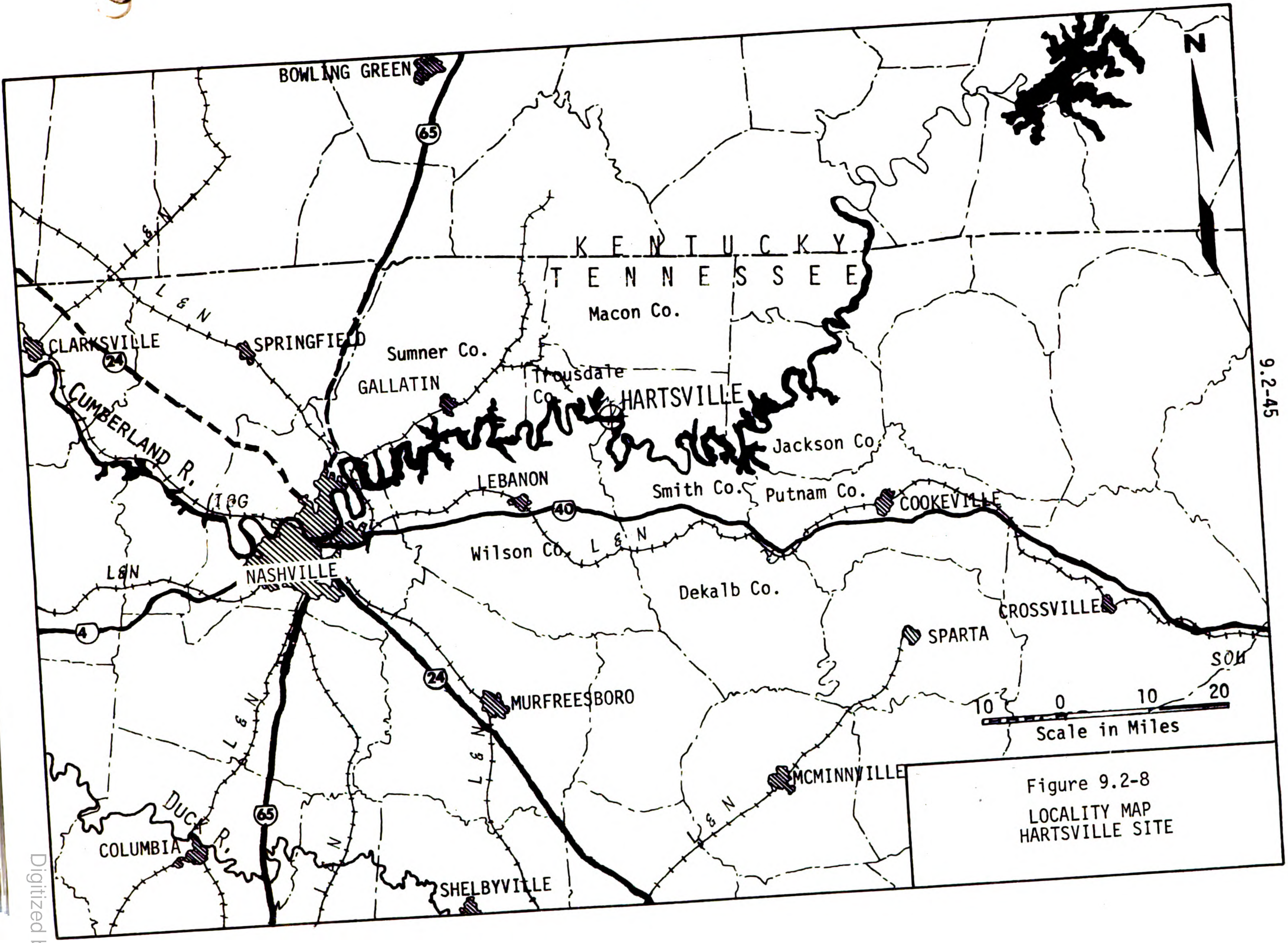
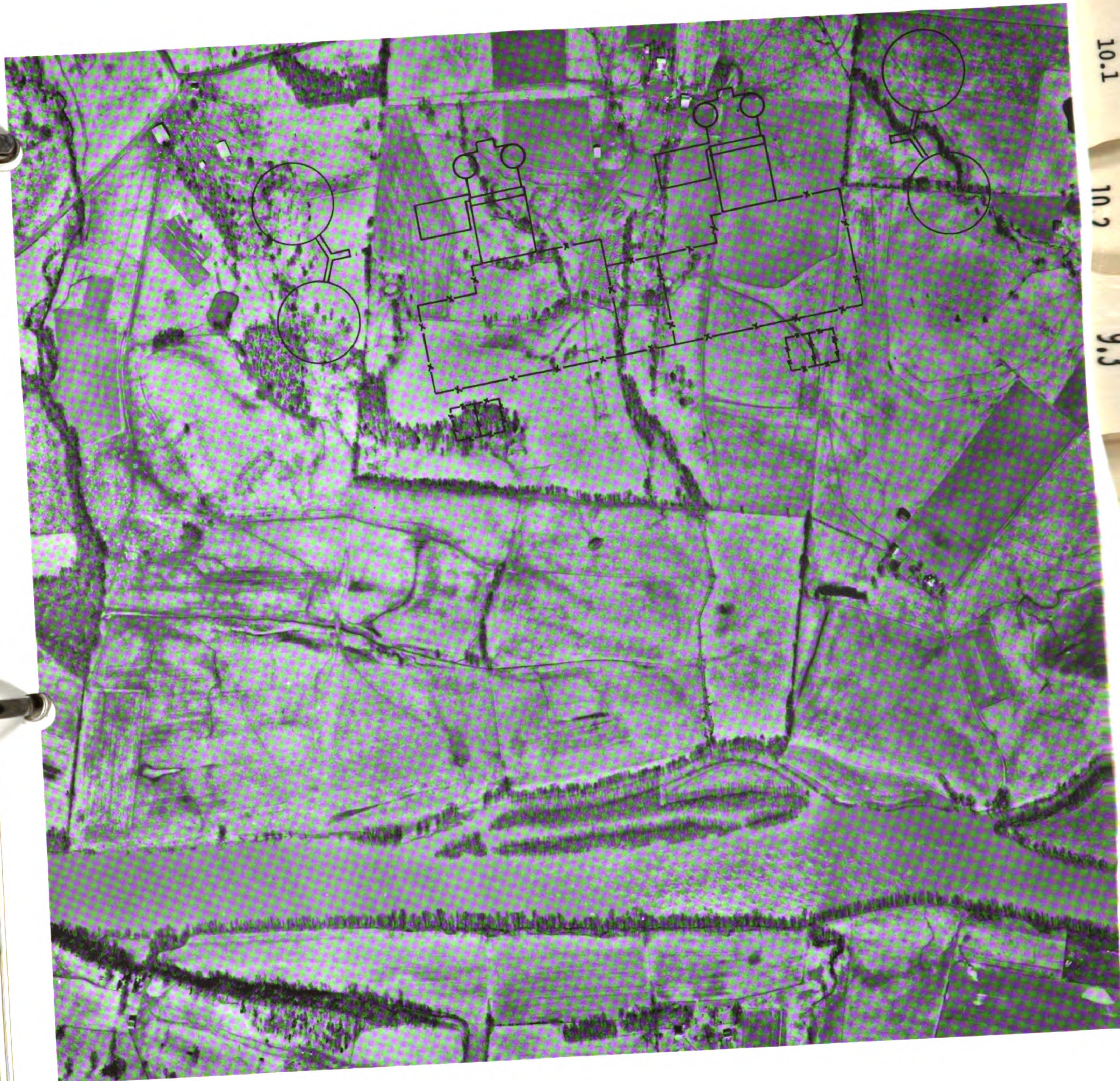


Figure 9.2-8
LOCALITY MAP
HARTSVILLE SITE



N

Figure 9.2-9

HARTSVILLE PLANT SITE
Cumberland River Mile 285R

800'   0   800'

APPROX.SCALE

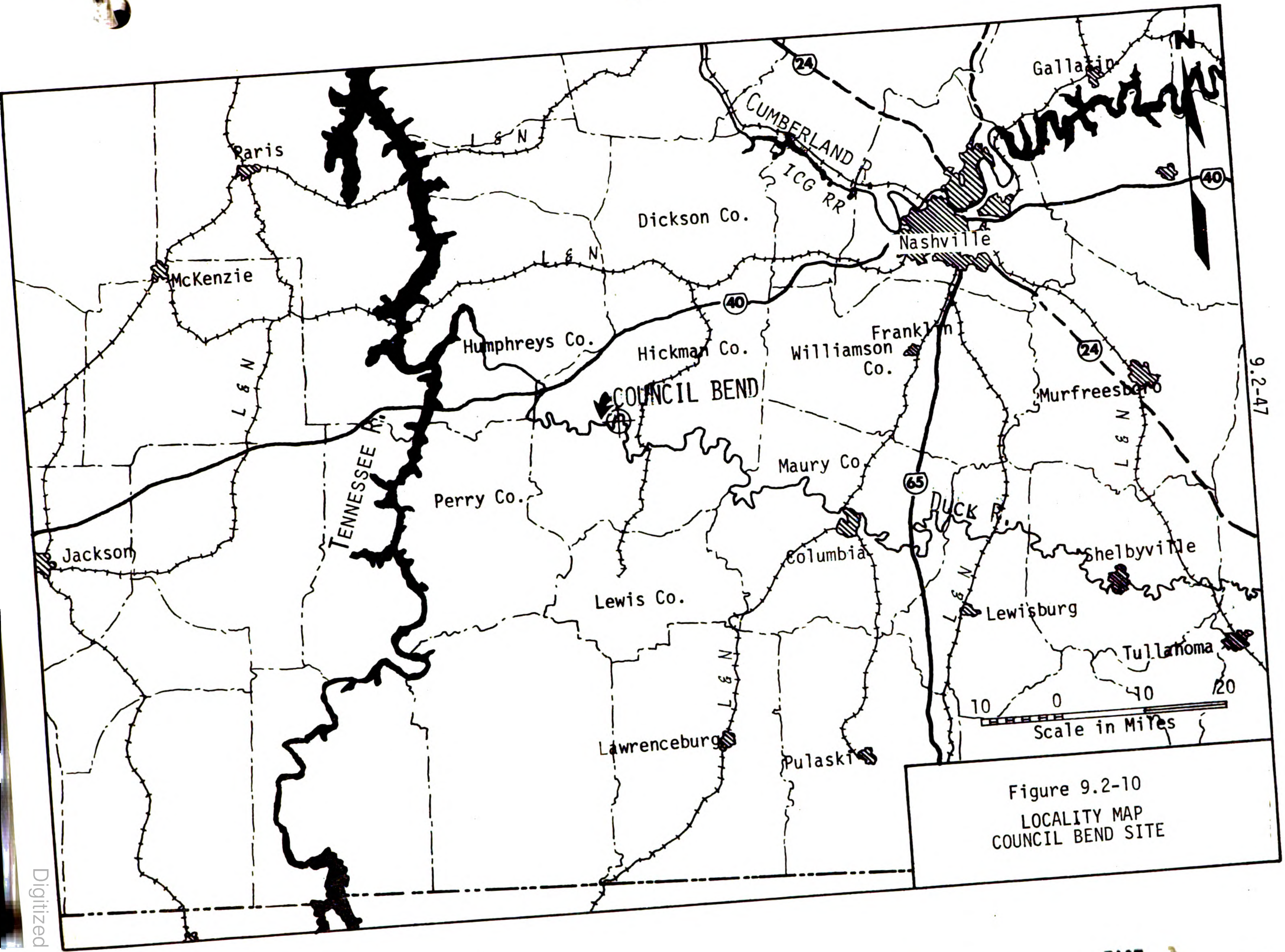


Figure 9.2-10
LOCALITY MAP
COUNCIL BEND SITE

N

Figure 9.2-11

COUNCIL BEND PLANT SITE

Duck River Mile 60L

800' 0 800'

APPROX. SCALE

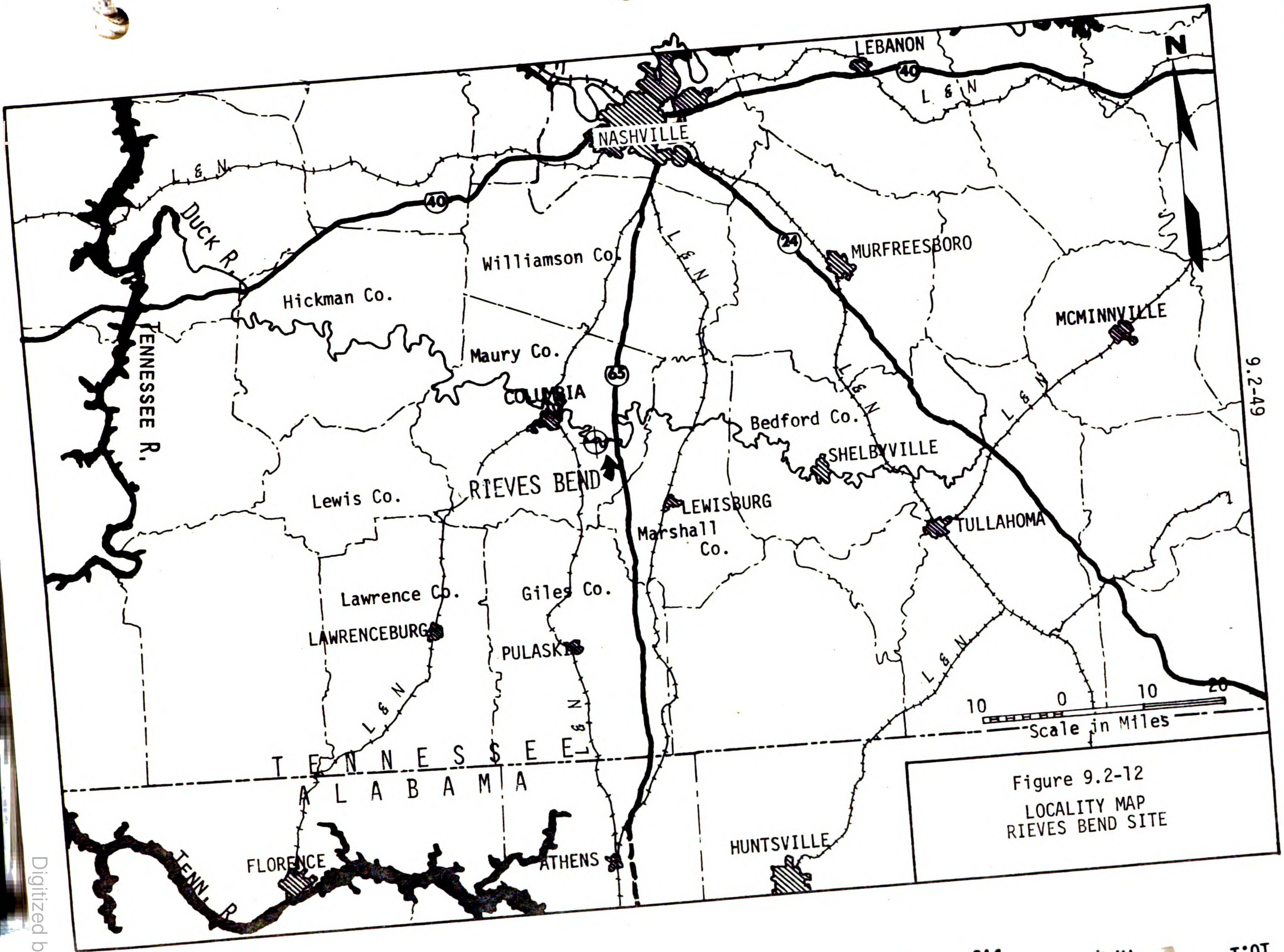


Figure 9.2-12
LOCALITY MAP
RIEVES BEND SITE

Figure 9.2-13

RIEVES BEND PLANT SITE
Duck River Mile 146L

800' 0 800'

APPROX. SCALE

N

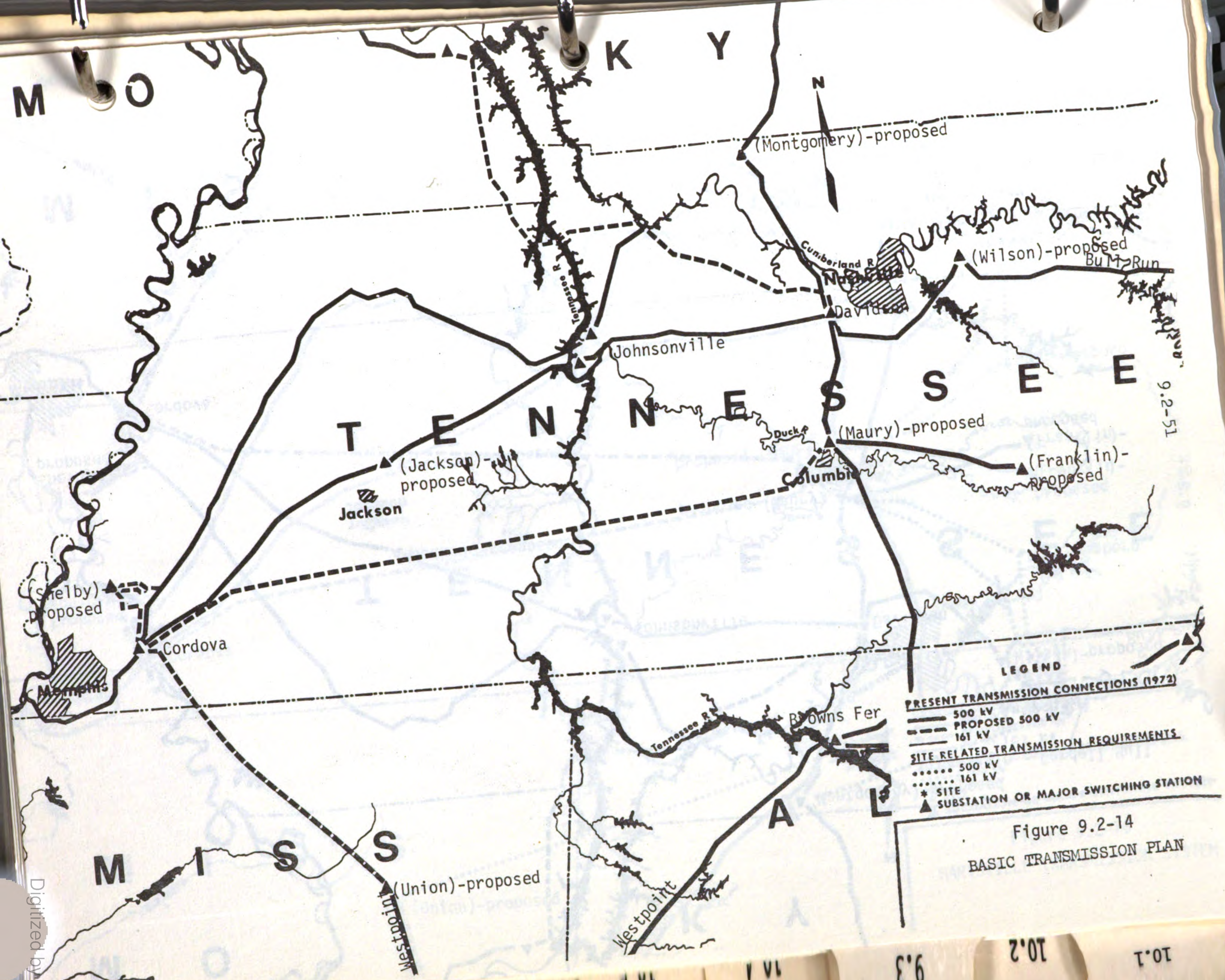


Figure 9.2-14

BASIC TRANSMISSION PLAN

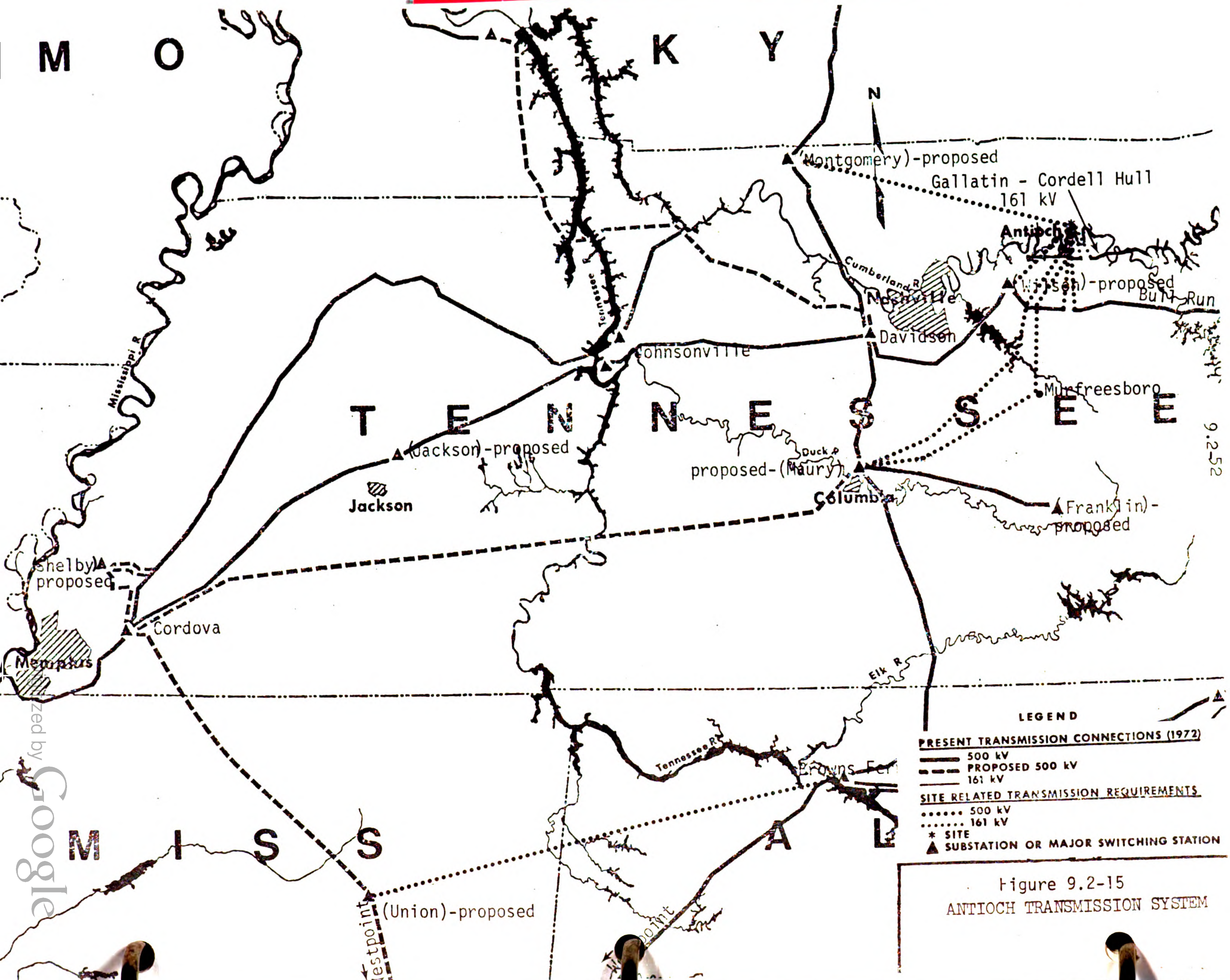


Figure 9.2-15
ANTIOCH TRANSMISSION SYSTEM

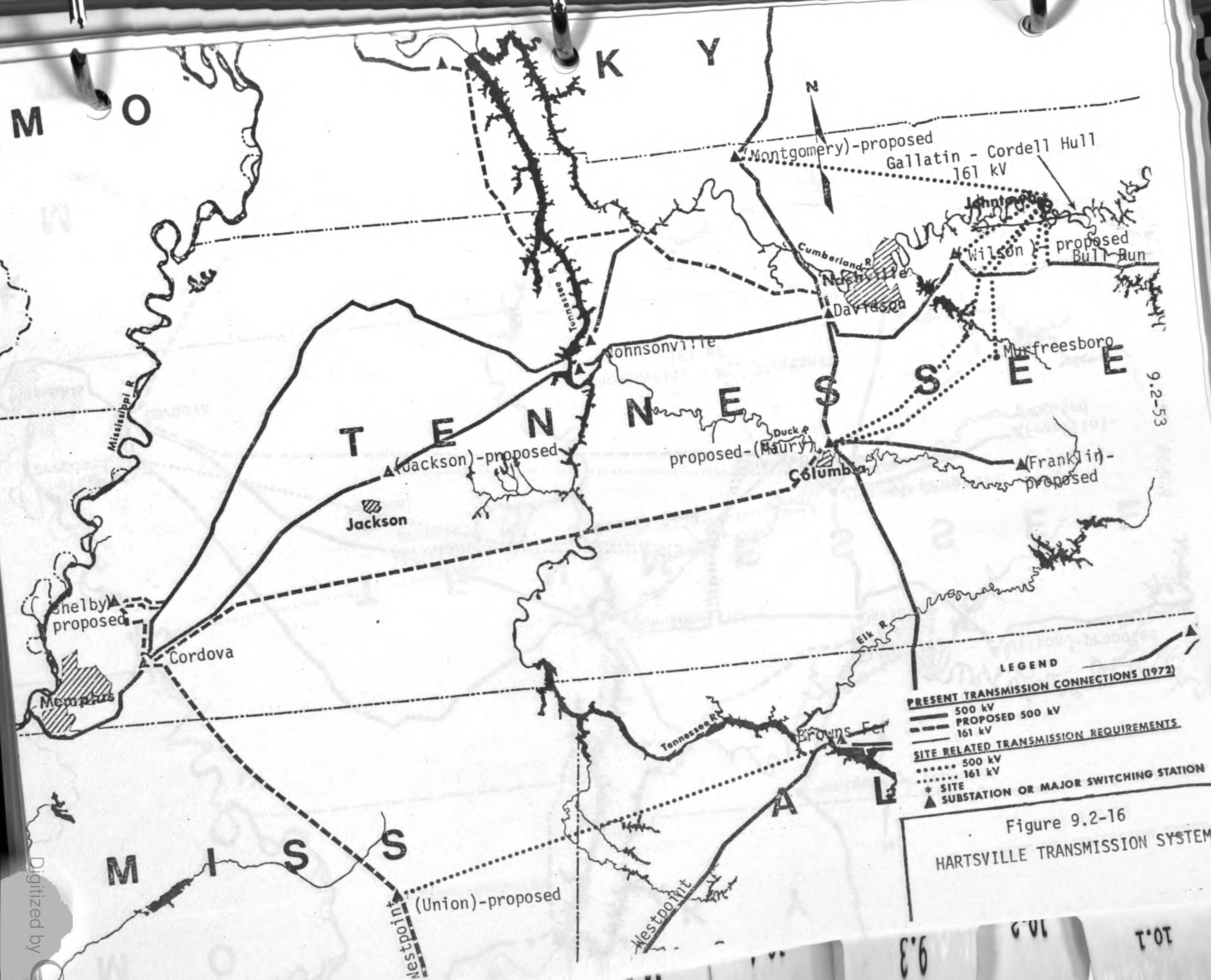


Figure 9.2-16

HARTSVILLE TRANSMISSION SYSTEM

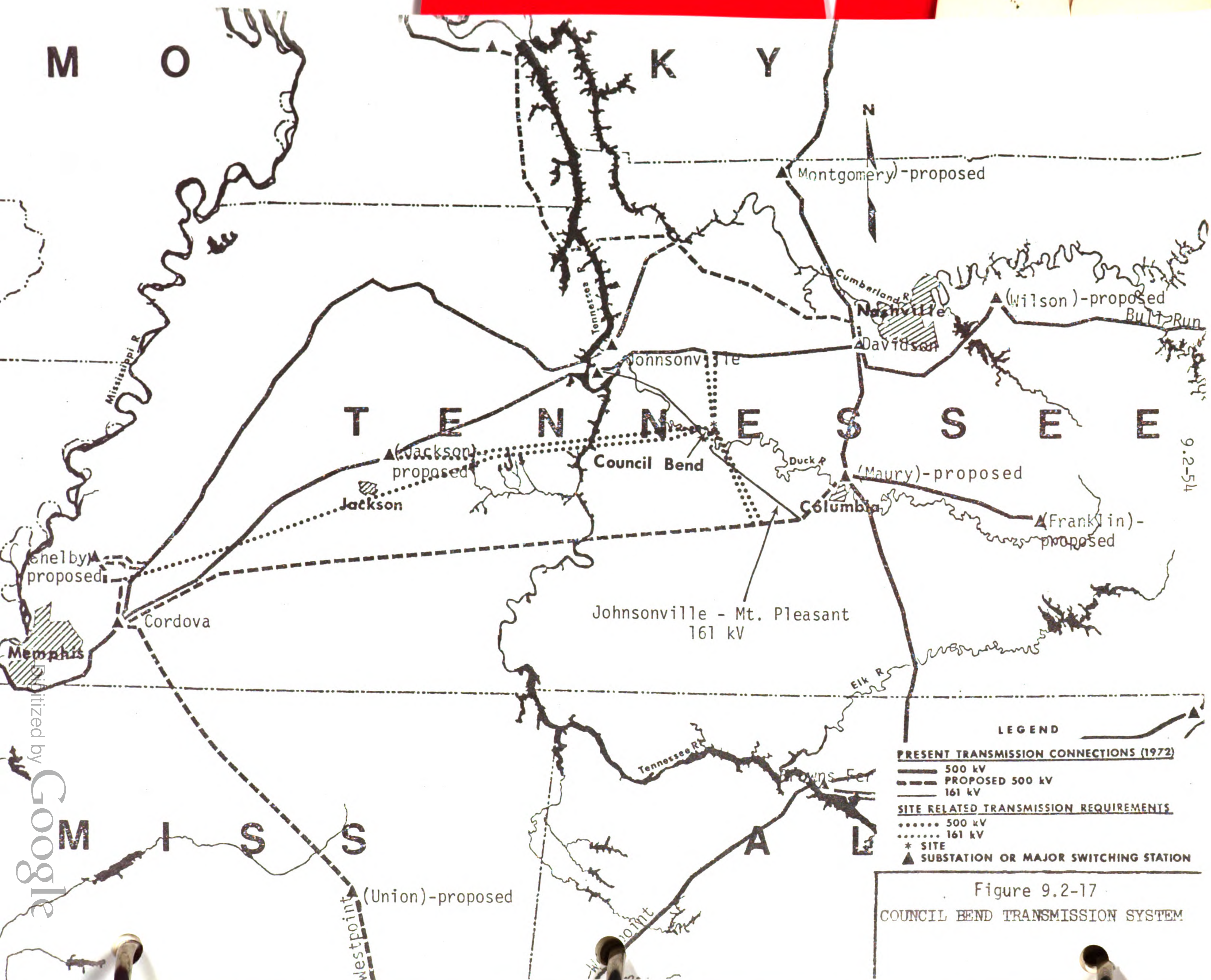


Figure 9.2-17
COUNCIL BEND TRANSMISSION SYSTEM

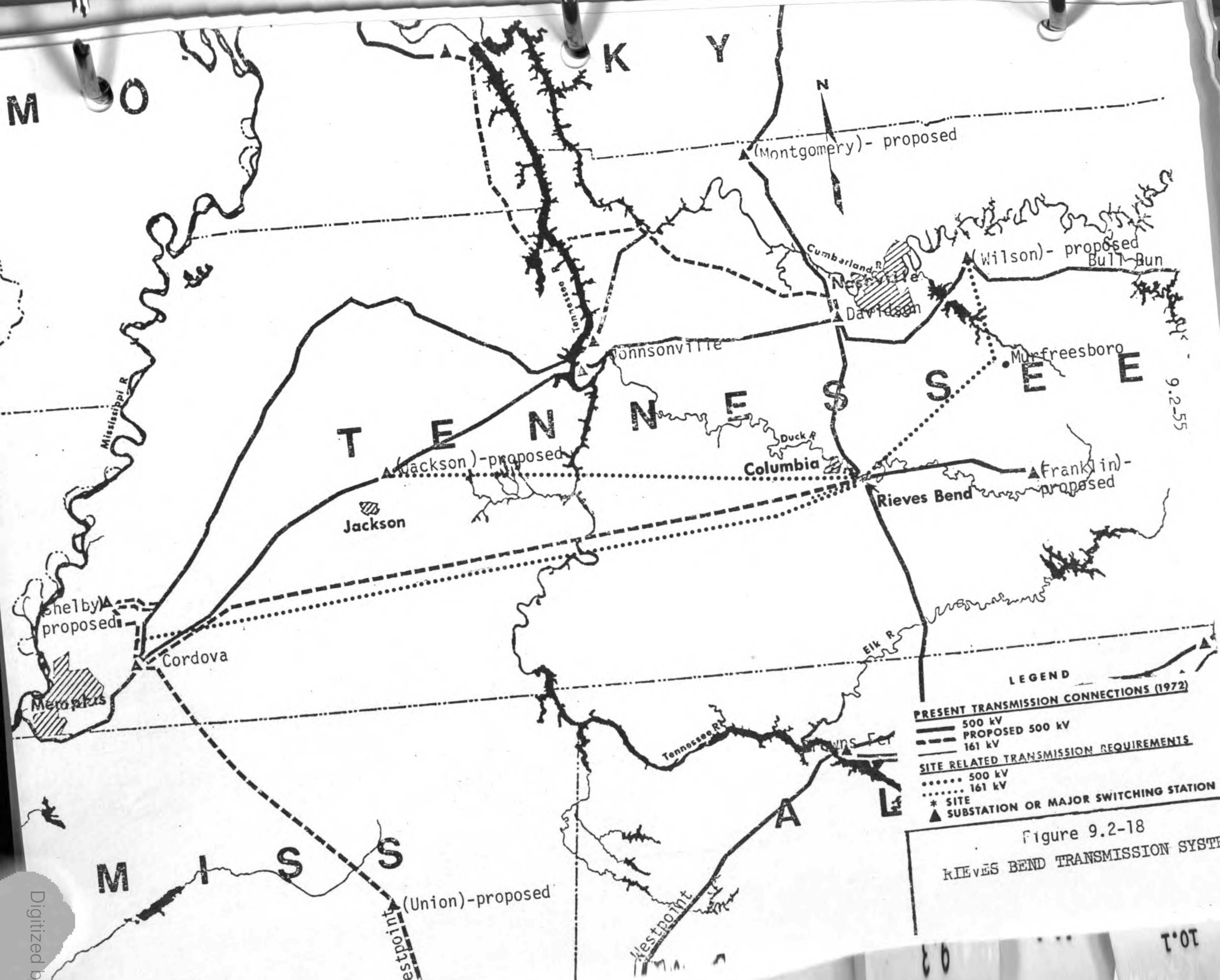


Figure 9.2-18
RIEVES BEND TRANSMISSION SYSTEM

10.1

9.3

10.0 Plant Design

9.3 Environmental and Cost-Related Factors for Candidate Site Alternatives -

9.3.1 Environmental Factors - The next major area in the evaluation process was the assessment of the environmental characteristics and potential impacts of each site. Table 9.3-1 lists a summary of the site characteristics for the four sites.

Land and Land Use - The location of the 4-unit facility at any site will entail a commitment of land resources for the generating plant and the associated transmission lines.

Based on TVA's experience, an exclusion radius of 4,000 feet was estimated to be adequate for this 4-unit plant. Consequently, the land area within the exclusion radius would be approximately 1,200 to 1,400 acres. The actual amount of land committed could exceed this amount since the actual properties acquired would depend on such factors as the topographical features of the site, property ownership, and special considerations such as road relocations.

Land Use in the Immediate Vicinity of the Sites - Each of the four sites is located in an area where the predominant land uses are for agricultural purposes and forest development and is in an area of low population density. Within a 10-mile radius only minor exceptions are found due to relatively small community developments. Development of the Antioch site would impose potential impacts due to its close proximity to the Old Hickory waterfowl refuge areas; however, no current land use has been identified that would preclude the use of any of these sites for the location of the plant.

Based on the above considerations the order of preference from the standpoint of existing land use compatibility in the immediate vicinity of the sites is:

1. Hartsville
2. Council Bend
3. Antioch
4. Rieves Bena

Transmission Land Use - Preliminary analysis of new transmission lines that would be required to interconnect the plant to the system shows the right of way requirements at Council Bend would be approximately 30 percent less than at the other sites. Unlike the complete alternation and commitment of land use for a generating plant, transmission rights of way involve only minor restrictions of present land uses. Except for the safety restrictions (no structures, buildings, etc.) of the land involved in the right of way easements, the property owners may continue to use the land for whatever uses they wish, and in fact, TVA encourages continued productive uses of rights of way.

Based on the estimated acreage of land required for transmission rights of way the order of site preference is:

1. Council Bend
2. Rieves Bend
3. Antioch
4. Hartsville

Population - Present and projected population information has been prepared for each site alternative and are shown in Figures 9.3-1 through 9.3-8.

Present population data is based on the 1970 census. Projected population data is based on county projections prepared by the Tennessee, Alabama, and Kentucky Social Sciences Advisory Committees. Each committee is a cooperative Federal-state group formed to agree on a common set of county projections for planning and development purposes based on projections for economic areas by the Bureau of Economic Analysis. The allocation of county population into the various segments was based on census maps and judgments from field experience.

Population Distribution - Population distribution curves have been prepared which compare the relative population concentrations for various radii. Figure 9.3-9 presents a comparison of each of the four sites and indicates the relative remoteness of the Council Bend site.

Population trends within the site areas have been projected to the year 2000 to determine the areas of expected rapid development during the life of the plant. A comparison of growth estimates on a percentage basis from 1970 to the year 2000 is shown below:

	Percent Increase in Population	
	10-Mile Radius	50-Mile Radius
Antioch	44	62
Hartsville	34	57
Council Bend	74	46
Rieves Bend	78	63

The population increase within the 10-mile radius is considered to be the more important of the two and indicates that the area in the vicinity of Hartsville is expected to have the smaller increase in

population. However, with the possible exception of the Rieves Bend site, all of the sites are remotely located and have no population growth trends that would preclude their use.

After considering current permanent and transient population distributions and projected populations to the year 2000, the overall ranking of the sites is as follows:

1. Council Bend
2. Hartsville
3. Rieves Bend
4. Antioch

Socioeconomic Impacts - At each of the candidate sites the construction of the plant will result in a large influx of workers into the respective areas. Significant impacts will be felt in the housing market and in the demand for public and private facilities, especially schools, and recreation.

Magnitude of Impact - The construction of the plant will involve approximately a 9-year construction period, and during its peak employment period there will be about 4,600 employees at the project. The project manpower requirements as a function of time are shown graphically in Figure 9.3-10.

Table 9.3-2 shows total employment, number of movers, and school age children for most of the construction period. The number of movers is based on an estimate of two categories of employees. The first category covers movers who are hired from outside the Nashville labor market area and have to move into the area to work. The second category covers movers within the Nashville labor market and within commuting distance but who choose to move for convenience or other reasons.

To estimate the first category of movers, the experience at TVA's Cumberland Steam Plant was used as a guide. Estimates were obtained of the employment level at which workers in the various crafts began to be "imported" from outside the Nashville labor market. Using the estimate of availability for the five largest crafts (carpenters, electricians, ironworkers, steamfitters, and operating engineers) and the projected employment of each of these crafts, the movers in the first category were estimated. This ranged from zero at the end of the first year to 2,000 at the peak.

A recent survey of construction employees at TVA's Sequoyah Nuclear Plant indicates that approximately 25 percent of the people moving into the area do so from a town that is within reasonable commuting distance. This factor was applied to the labor force remaining after the first category was subtracted to estimate the second category of movers. This ranges from 300 at the end of the first year to over 600 at the peak.

The total number of movers shown in Table 9.3-2 is the sum for the two categories discussed above and varies from 300 in the first year of the project to 2,600 at the peak.

Past surveys indicate that the proportion of movers who bring their families has ranged from about 50 percent to 75 percent. Comparing the location of each of the four sites with the other projects and taking into account the number of movers coming from relatively long distances, it is estimated that 65 percent of the movers will bring their families. There is approximately one school age child per family; therefore, the number of school age children ranges from 200 after the first year to 1,700 at the peak.

Housing Availability - Estimates of adequate or sound vacant housing in the areas considered are not available. However, the 1970 Census of Housing reports vacant housing by availability of plumbing facilities. Although conventional housing is still the most desired type of accommodation, mobile homes are increasingly being used by TVA construction workers. In 1968, 20 percent of the movers surveyed lived in mobile homes as compared with 45 percent in 1972. Based on this trend, mobile homes are likely to be the predominant mode of housing at each site.

Impact on Schools - School districts in and near previous TVA projects have used available Federal assistance to cover additional costs of operation. However, capital outlay costs for additional classrooms, equipment, and buses are beginning to cause major problems for local and state agencies. Previously, capital outlay expenditures were made which took care of the temporary impact enrollment due to construction. These same facilities were used later to accommodate normal growth or to accomplish school consolidation.

Based on an evaluation of the probable impacts on schools and housing at each of the proposed sites, the Rieves Bend site would have the greatest adaptability to cope with the large-scale immigration. Rieves Bend, due to its proximity to Columbia, Tennessee, should require only one-fifth the number of temporary classroom facilities for schools as the other sites. However, mitigation of the housing impacts is a problem basic to each of the sites and can only be resolved by a vigorous and comprehensive housing plan. Therefore, the order of minimal socio-economic impact is not clearly defined and would be of little relative difference except in the case of schools which would undoubtedly favor Rieves Bend.

Historical Significance - Based on a review of the National Register of Historic Places, state preservation plans, and detailed onsite consultant reports[a] the Hartsville site was judged to have more potentially significant historical developments than the other candidate sites. Development of Hartsville would require coordination with appropriate Federal, state, and local officials to ensure the proper consideration of any structures that might be affected by plant construction which are determined to be significant under the National Historic Preservation Act of 1966.

The procedures outlined by the National Park Service, Department of the Interior,[b] provide that historical and environmental considerations may be combined in a single document, the environmental statement, which will be distributed widely for comment by appropriate Federal, state, and local agencies, and interested persons. After consideration of all comments received, a final decision can be made regarding the historical, architectural, archaeological, and cultural significance of properties within the area affected by the project.

Archaeological Significance - Each of the four sites were investigated by TVA's archaeological consultants. The Antioch and Hartsville sites were surveyed by Dr. C. F. McCollough. The Council Bend and Rieves Bend sites were surveyed by David R. Evans and David J. Ives, who are consulting archaeologists. These investigations consisted principally of the identification of archaeological sites and historic features which could be affected by steam plant construction and operation at each site. These investigations revealed that the Hartsville site is a relatively rich archaeological location and

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a. Dr. Major C. R. McCollough, Research Assistant Professor, Department of Anthropology, University of Tennessee, Archaeological Surveys of Antioch and Johntown Steam Plant sites on Old Hickory Reservoir near Gallatin, Tennessee, September 15, 1972.

b. 39 Fed. Reg. 6402-77 (1974).

the most significant of the four sites from an archaeological standpoint.

Ecology - The possible biological impacts at the candidate sites were assessed by TVA in cooperation with area universities and consisted of surveys conducted in six major categories, including vegetation, wild land, reptile and amphibian habitat, upland game, waterfowl, and fisheries. Based on the results of these investigations, the Hartsville site seemed to present the least potential for ecological impacts, and where value judgments were made it ranked lowest of the four. In contrast, it seems to possess the highest ecological potential and therefore has the capacility to develop a more diverse and stable ecological community on the unaffected areas of the site. Consultants used in these studies are listed below.

1. Vegetational Survey, Antioch Site, Dr. S. K. Ballal, T.T.U. and Allen Skorepa, University of Tennessee

2. Vegetational Survey, Hartsville Site, (same as above)

3. A survey of the Vascular plants of the Rieves Bend area of the Duck River, Maury County, Tennessee, Dr. G. E. Hunter, T.T.U. and Donald Ott, University of Tennessee

4. Wild Land Environmental Assessment, Roger W. Bollinger, TVA; Dr. D. H. Synder, Austin Peay State University

5. Reptile and Amphibian Habitat, C. Holden Brink, TVA; Dr. Glenn Gentry (retired) Nashville, Tennessee

6. Fish Population Inventory of Two Areas of the Cumberland River - Frank J. Bulow - R. Don Estes, Department of Biology, T.T.U.

Hydrology - Hydrological assessment of the Cumberland and Duck Rivers had not been clearly defined at the time of site assessment due to the potential effects of future reservoir impoundments and their operation. The hydrologic features of the Cumberland River sites would be affected by the operation of the newly constructed Cordell Hull Dam. If the proposed Normandy and Columbia Dams are constructed as planned, the hydrologic characteristics of the Duck River sites would be significantly altered.

Water Use Compatibility - The requirements of the plant would have potential impacts on water use in three principal ways.

1. Alteration of the physical and chemical characteristics of the water in the immediate vicinity of the plant
2. Evaporation of substantial quantities of water for operation of cooling towers
3. Discharge of small amounts of radioactive liquid effluents

An assessment of the effect of thermal and chemical plant discharges on the waters in the immediate vicinity of the sites would depend upon the effect of the reservoir impoundment. Due to the differences in the average annual and minimum flows between the Cumberland and Duck River sites, it would be more difficult for the blowdown from cooling towers to avoid violation of current thermal standards on the Duck River sites. A system that cleans up and recycles cooling tower blowdown would likely be required at these sites to stay within standards.

An evaporation loss of 150 ft^3/s from the closed-cycle natural draft cooling towers for this plant would have adverse effects on project benefits for the Normandy and Columbia projects, particularly those for water supply and recreation. The Duck River area, particularly in the vicinity of Columbia, Tennessee, has experienced severe water supply shortages during low-flow periods in the past. The evaporation rate of 150 ft^3/s for this plant represents a major water use conflict with this need.

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10.0 Plant Design Alternatives

The withdrawal of this amount of water from the Columbia Reservoir could also result in a 4- to 7-1/2-foot reduction in the recreational pool elevation during dry periods. This much drawdown could detract from the full recreational development of the Columbia Reservoir and consequently is a major disadvantage of selection of the Rieves Bend site for the location of this plant.

The effect of evaporation losses on the Cumberland sites does not pose the same degree of impact and could be avoided entirely by modification in power generation on the run-of-the-river hydro projects; therefore, from the standpoint of water use compatibility, the Cumberland River sites are more favorable.

The third potential impact, the discharge of radioactive liquid effluents, will be discussed as part of the total radiological releases.

Climatology and Meteorology - Onsite meteorological data were not available at any of the candidate sites at the time of site assessment. However, based on an evaluation of the regional climatology and known meteorology at TVA's Browns Ferry, Paradise, and Gallatin plants as well as a review of the National Weather Service data, a relative judgment of the meteorological and site dispersion factors for each site was made. On the basis of these judgments, Council Bend and Rieves Bend sites would have somewhat more favorable site dispersion characteristics than Hartsville and Antioch.

Radiological Impact for Normal Plant Operation - Gaseous Effluents - Based on the preliminary estimates of the meteorological conditions postulated at each site, there is reasonable assurance that the proposed design objectives of Appendix I to 10 C.F.R. Part 50 for routine noble gas and particulate releases would be met at any of the sites.

Based on the combination of postulated meteorological conditions and the population distribution in the vicinity of each site, the estimated population dose within a 50-mile radius of the Council Bend site would have the lowest value by a factor of 2 when compared to the Rieves Bend and Hartsville sites and about a factor of 3 at Antioch.

<u>Radiological Impact for Normal Plant Operation - Liquid Effluents</u> - The liquid radwaste treatment system for the proposed plant will meet the design objectives of proposed Appendix I. Comparison of the Cumberland River sites, Antioch and Hartsville, indicates little difference between them from the viewpoint of doses due to radionuclides in liquid effluents. Liquid effluents from Hartsville would affect two public water supplies that would not be affected by releases at Antioch. However, radionuclides released at Antioch would contribute a larger dose at Nashville, Tennessee, due to the shorter decay time.

On the Duck River the Council Bend site is favored over the Rieves Bend site due to larger dilution, greater distance to the first water supply, and a smaller number of persons served by the public water supplies.

When comparing the Council Bend site with the Cumberland River sites, Council Bend was judged to be a better choice even though the Cumberland River has a dilution flow about a factor of 65 higher than the Council Bend site. This is due to the smaller number of people served by downstream water supplies from the Council Bend site.

While the Council Bend site could be considered more favorable in relation to the radiological impact due to normal plant operations, it should be noted that liquid radionuclide releases from all plant sites will be as low as practicable and well within Federal guidelines; and, therefore, these releases will result in an insignificant environmental impact.

Transportation - Each of the four candidate sites would require some improvements in both rail and highway access facilities to accommodate the activities associated with normal plant operations. These operations will involve the transport of new fuel to the site, shipment of spent fuel to reprocessing plants, and the shipment of low-level radioactive wastes for offsite burial.

One significant transportation factor in nuclear plants is availability of barge transportation. Barge access to the Council Bend and Rieves Bend sites is not available. Development of these sites for the plant would require substantial improvements in existing highways to obtain a roadway base capable of supporting the overland transport of reactor vessels. Preliminary assessments of the alternative routes indicate that approximately 40 miles of road improvements would be required for access to Council Bend and about 80 miles for Rieves Bend.

Therefore, an overall assessment of the transportation facilities would favor the Cumberland River sites, Antioch and Hartsville, due primarily to the availability of barge access.

9.3.2 Cost Factors - Cost estimates were prepared in three categories of site-related development costs: (1) land acquisition, (2) site preparation, and (3) transmission costs. The total cost of locating the power plant at each of the candidate sites in increasing order is tabulated below in terms of 1972 dollars:

1. Hartsville	\$108.9 million
2. Rieves Bend	
a. With Columbia Dam	\$114.9 million
b. Without Columbia Dam	\$120.1 million
3. Antioch	\$134.7 million
4. Council Bend	\$137.2 million

As indicated, the Hartsville and Rieves Bend sites have essentially the same cost of development with the magnitude of the difference ($6.0 million) being within the accuracy of the estimate. In order to fully examine all foreseeable factors influencing the relative economic cost of developing each site, the Rieves Bend site was evaluated based on two alternative courses of action. The alternatives posed are a result of the proposed Duck River Development Project. This project incorporates two impoundments of the Duck River, one of which is located near Columbia, Tennessee, and near the Rieves Bend site. With the construction of the proposed Columbia Dam, considerable economic savings could be realized in the areas of land acquisition and secondary cooling water supplies at Rieves Bend. The Rieves Bend cost estimate includes $8.9 million penalty for a recycling system for cooling tower blowdown.

Due principally to the additional expense of an adequate foundation at the Council Bend and Antioch sites, the developmental cost of these sites would be higher than the Hartsville and Rieves Bend sites. While the cost of transmission facilities at the Council Bend site results in a savings ranging from about $13 to $20 million, it requires more foundation treatment and a makeup reservoir for low-flow periods and would likely require a recycling system on the cooling towers. These and other factors more than offset the transmission advantage of Council Bend.

SUMMARY

From the consideration of engineering feasibility, environmental impact, and economics, and after assessing the merits of each site, the Hartsville site was judged to offer more favorable overall characteristics with the least environmental impacts. Listed below are the principal factors considered in arriving at this conclusion.

Economics

Hartsville offers cost advantages over the other candidate sites which range from $6 million at Rieves Bend (with the Columbia Dam) to $28 million at Council Bend.

Engineering Feasibility

From the standpoint of engineering feasibility, Hartsville and Rieves Bend are preferred due principally to extensive foundation treatment required at the Antioch and Council Bend sites. The underlying geological structure generally favors the Rieves Bend site due to the presence of bentonite seams at Hartsville. However, removal of the bentonite material is reflected in the developmental cost of this site and is not considered to be a significant disadvantage to Hartsville.

Ecology

The Hartsville site exhibited the lowest potential for ecological impacts of any of the sites considered.

Land and Water Use Compatibility

Unlike other candidate sites Hartsville has no present or projected land or water use conflicts.

Historical Significance

Based on reviews of the National Register of Historic Places, state coordination and onsite studies, the Hartsville site exhibits more potentially significant historic developments than the other candidate sites.

Archaeological Significance

Hartsville contains several more potentially significant archaeological sites than the other sites considered. These archaeological

sites will be explored and excavated as necessary to preserve their significant historical value. 10.1 This activity will add somewhat to the cost of developing this site, but this cost has been factored into the development cost of the site. 10.2 Thus, the archaeological features are not considered to be a significant negative siting factor since public ownership provides the opportunity for the survey and salvage of potentially significant artifacts that might not otherwise be realized. 10.3

Population

The population distribution within a 10-mile radius of Hartsville is second only to Council Bend and is well within the low population distributions of present TVA nuclear projects.

Transmission

The only significant disadvantage of Hartsville on a comparative basis would be transmission line requirements. Based on the results of preliminary transmission system analysis, the need for additional transmission facilities would be less at the Council Bend site. The cost of providing the additional amount of transmission facilities at Hartsville is reflected in the comparative cost estimates of each site. Even with the inclusion of additional transmission facilities, Hartsville offers a $28 million savings over Council Bend. It is recognized that the use of the land required for the rights of way associated with the additional 135 miles of transmission lines at Hartsville could present some minor restrictions in land use. However, after considering the offsetting disadvantages of Council Bend in the areas of ecological value and potential land and water use conflicts, the net impact posed by longer transmission lines at Hartsville is judged to be significantly smaller.

Based on the predominant factors discussed, the Hartsville site offers the balance of the significant engineering, economic, and environmental factors and is the preferred location for the nuclear units.

Table 9.3-1

ALTERNATIVE SITES - SUMMARY OF CHARACTERISTICS

Major Factors Considered	Alternative Sites: Cumberland River: Antioch	Cumberland River: Hartsville	Duck River: Council Bend	Duck River: Rieves Bend
Site Characteristics				
River mile	259	385	60	146
Acres required	950	1,400	1,400[a]	1,530[a,b]
TVA-owned	0	0	0	0
Access				
Highway - miles				
New	<1.0	1.0	2.0	5.0
Recond.	0	0.5	40	80
Rail - miles				
New	8.6	6.4	3.0[c]	2.5[d]
Barge feasibility	yes	yes	no	no
Transmission				
Miles -				
500 kV	377	397	266	379
161 kV	8	8	3	-
ROW - acres[e]	9,240	9,720	6,490	9,190
Engineering Feasibility				
Seismic	(Basically the same for all sites)			
Faulting				
Proximity - miles	27W	36W	25NW	7W
Condition	inactive	inactive	inactive	inactive
Detailed study req'd.	no	no	no	no
Foundation Conditions				
Problems:	Excavation of pinnacled rock, possible water leaks, treatment of cavities	Bentonite beds will require careful selection of plant grade	30' cavernous zone with cavities as large as 10'	None serious
Grouting	extensive	normal	extensive	normal

Table 9.3-1
(continued)

X17-X20 ALTERNATIVE SITES - SUMMARY OF CHARACTERISTICS

Major Factors Considered	Alternative Sites: Cumberland River: Antioch	Cumberland River: Hartsville	Duck River: Council Bend	Duck River: Rieves Bend
Flooding				
Plant grade	510	538	510	700
Max. possible flood and max. wave runup	492.8	520.9	513.1	648.8
Failure in OBE (coincident with 1/2 max. possible flood)	510	530	511	637
Environmental Impacts				
Land Use Conflicts				
Present	waterfowl refuge	none	none	none
Projected	same	none	home development	Columbia res. development
Population				
10-mile radius				
1970	21,195	12,320	7,365	31,185
2000	30,605	16,445	12,825	55,530
50-mile radius				
1970	897,265	893,360	550,955	775,875
2000	1,450,255	1,403,975	801,940	1,218,075
Nearest town				
Name	Hartsville	Hartsville	Centerville	Columbia
Distance	8 mi - ENE	5 mi - NW	5 mi - SE	5 mi - NW
1970 population	2,243	2,243	2,592	21,471
Nearest major urban concentration	Nashville	Nashville	Nashville	Nashville
Distance	33 mi - WSW	43 mi - WSW	46 mi - ENE	40 mi - NNE
1970 population	448,444	448,444	448,444	448,444

10.1

10.2

Table 9.3-1
(continued)

X17-X20 ALTERNATIVE SITES - SUMMARY OF CHARACTERISTICS

Major Factors Considered	Alternative Sites: Cumberland River: Antioch	Cumberland River: Hartsville	Duck River: Council Bend	Duck River: Rieves Bend
Construction Employment				
7-1/2-year avg.	2,400	2,400	2,400	2,400
Peak	4,600	4,600	4,600	4,600
Total Population Increase				
7-1/2-year avg.	2,750	2,750	2,750	2,750
Peak	6,000	6,000	6,000	6,000
Housing Availability				
No. units - 1970	>800	>800	>700	>700
Impact on Schools				
Portable classrooms needed at peak[f]	50-60	60	50	10
Historical Sites				
No. of sites[g]	2	1	none	16
Distance to nearest	4 mi	2 mi	-	5 mi
Archaeological Sites				
No. of sites	2	9	-	5
No. of surface indicators	2	9	2	-
Ecology				
Vegetation	No rare or unusual species. Site consists of mostly exposed lime-stone, thickets, and wood lands. No significant ecological losses.	No rare and endangered species. No significant ecological losses.	No rare and endangered species. No unique plant habitat or community. About half the area is wooded--remainder is in agriculture.	No rare and endangered species were observed. No unique floral asso-ciation. No significant ecological losses.
Wild land	Low wild land value.	Low wild land value.	High wild land value.	No significant impact.

Table 9.3-1
(continued)

X17-X20 ALTERNATIVE SITES - SUMMARY OF CHARACTERISTICS

Major Factors Considered	Alternative Sites: Cumberland River: Antioch	Hartsville	Duck River: Council Bend	Rieves Bend
Ecology (cont'd)				
Mammals and birds	Low habitat diversity. No significant impact.	No significant impact.	High habitat diversity. No significant impact.	High habitat diversity. No significant impact.
Reptiles and amphibians	No rare or endangered species. Low ecological value.	No rare or endangered species. Minimal ecological losses.	No rare or endangered species. High ecological value.	No rare or endangered species. High ecological value.
Upland game	No rare or endangered species. Ranks thirds in hunting value.	Ranks lowest in hunting value. No significant impact.	No rare or endangered species. Highest site in hunting value.	Second highest site in hunting value.
Waterfowl	Least significant impact.	No significant impact.	Highest impact would occur.	No significant impact.
Fisheries	No rare or endangered species. No significant impact.	No rare or endangered species. No significant impact.	One rare fish species may exist. High habitat diversity.	No rare or endangered species. High habitat diversity.
Hydrology				
Streamflow - ft^3/s				
Mean daily	17,500	17,000	3,100	1,710
Min. daily	570	560	325	135
Proximity to Support Facilities				
Reprocessing Plants (road miles ±10)				
Barnwell, SC	430	435	435	395
Morris, IL	410	415	470	450
West Valley, NY	645	650	705	685

Table 9.3-1

(continued)

X17-X20 ALTERNATIVE SITES - SUMMARY OF CHARACTERISTICS

Major Factors Considered	Alternative Sites: Cumberland River: Antioch	Cumberland River: Hartsville	Duck River: Council Bend	Duck River: Rieves Bend	
				Without Col Dam	With Col Dam
Offsite Disposal Facilities (road miles ±10)					
Barnwell, SC	430	435	435	395	
Morehead, KY	275	280	340	320	
Economics - $ x 10^3 (1972 Dollars)					
Land and associated cost	1,085	1,106	1,712	3,319	215
Site preparation	54,933	25,081	73,535[g]	42,047[h]	40,027[h]
Transmission	78,675	81,715	61,960	74,692	74,692
Total	134,693	107,902	137,207	120,058	114,929
Mineral rights	-	1,000	-	-	-
Total site cost	134,693	108,902	137,207	120,058	114,929
Difference	25,791	base	28,305	11,156	6,027

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a. Does not include requirements for makeup water reservoir.
b. Assumes Columbia Dam not constructed.
c. Also requires rail bridge across river.
d. Also requires crossing two Columbia Reservoir embayments.
e. Based on 200-foot right of way width for 500 kV, 100-foot right of way for 161 kV.
f. Cost per portable classroom - $15,000.
g. Sites identified in the National Register of Historic Places and those identified in field investigations.
h. Includes estimated operating cost for recycling system.

Table 9.3-2

TOTAL CONSTRUCTION EMPLOYMENT, TOTAL MOVERS,

AND ASSOCIATED POPULATION AND SCHOOL AGE POPULATION

Time Period	Employment	Movers	Population Increase School Age	Population Increase Total
1	1,200	300	200	700
2	2,700	1,100	700	2,500
3	4,000	2,100	1,400	4,900
4	4,600	2,600	1,700	6,000
5	3,700	2,000	1,300	4,600
6	1,700	700	450	1,600

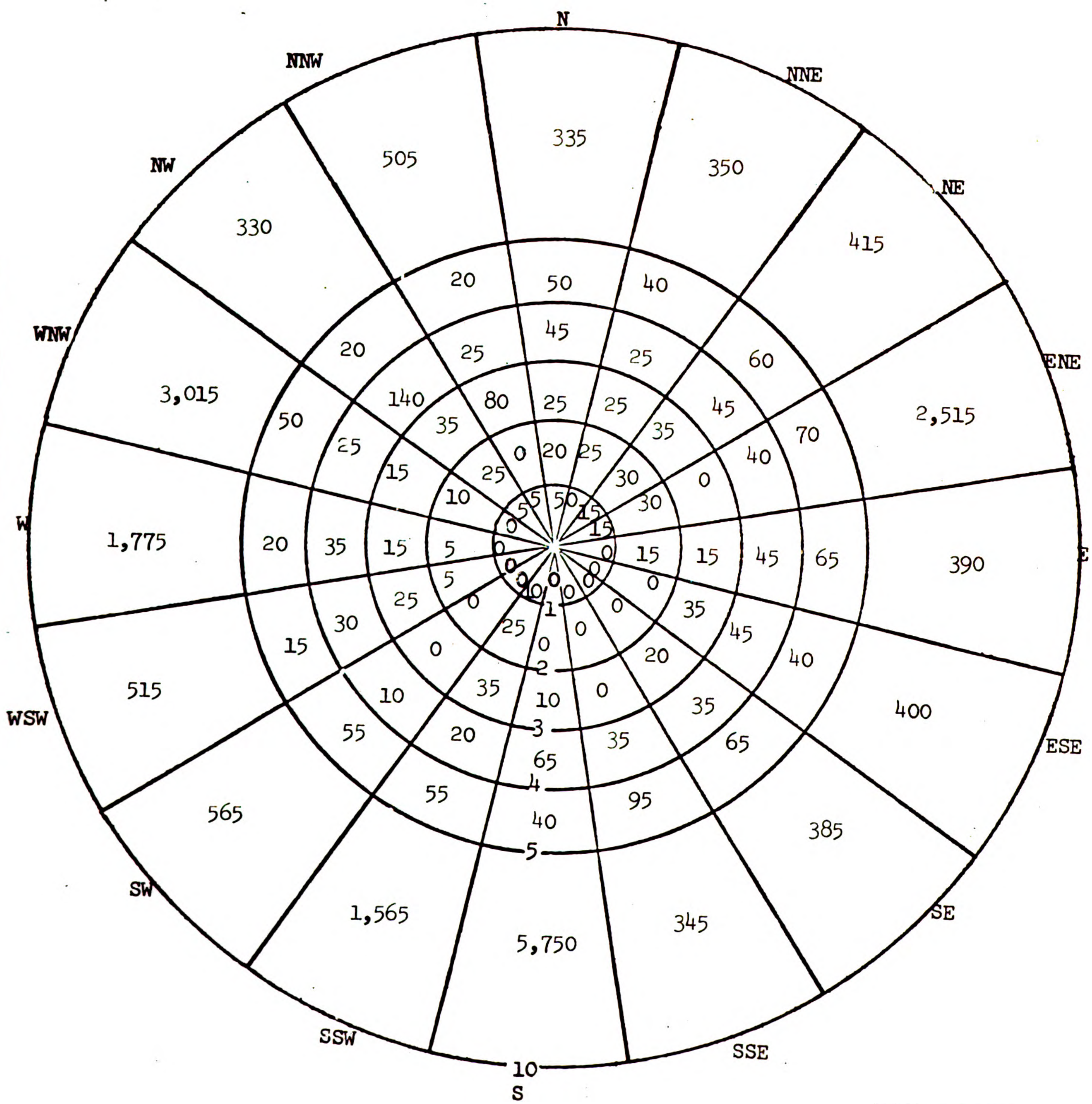

Figure 9.3-1

POPULATION DISTRIBUTION
ANTIOCH SITE
Year 1970

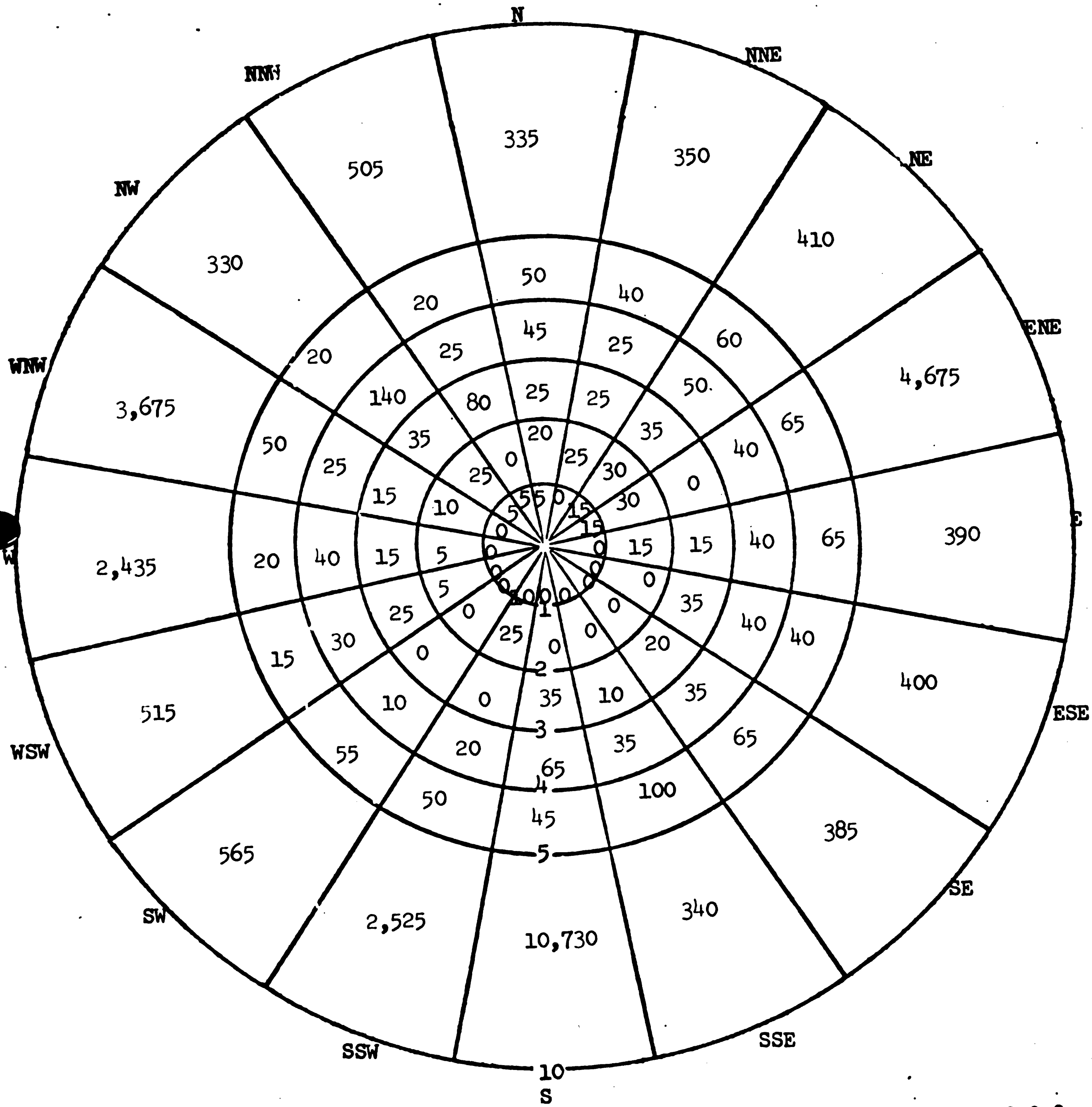

Figure 9.3-2

POPULATION DISTRIBUTION
ANTIOCH SITE
Year 2000

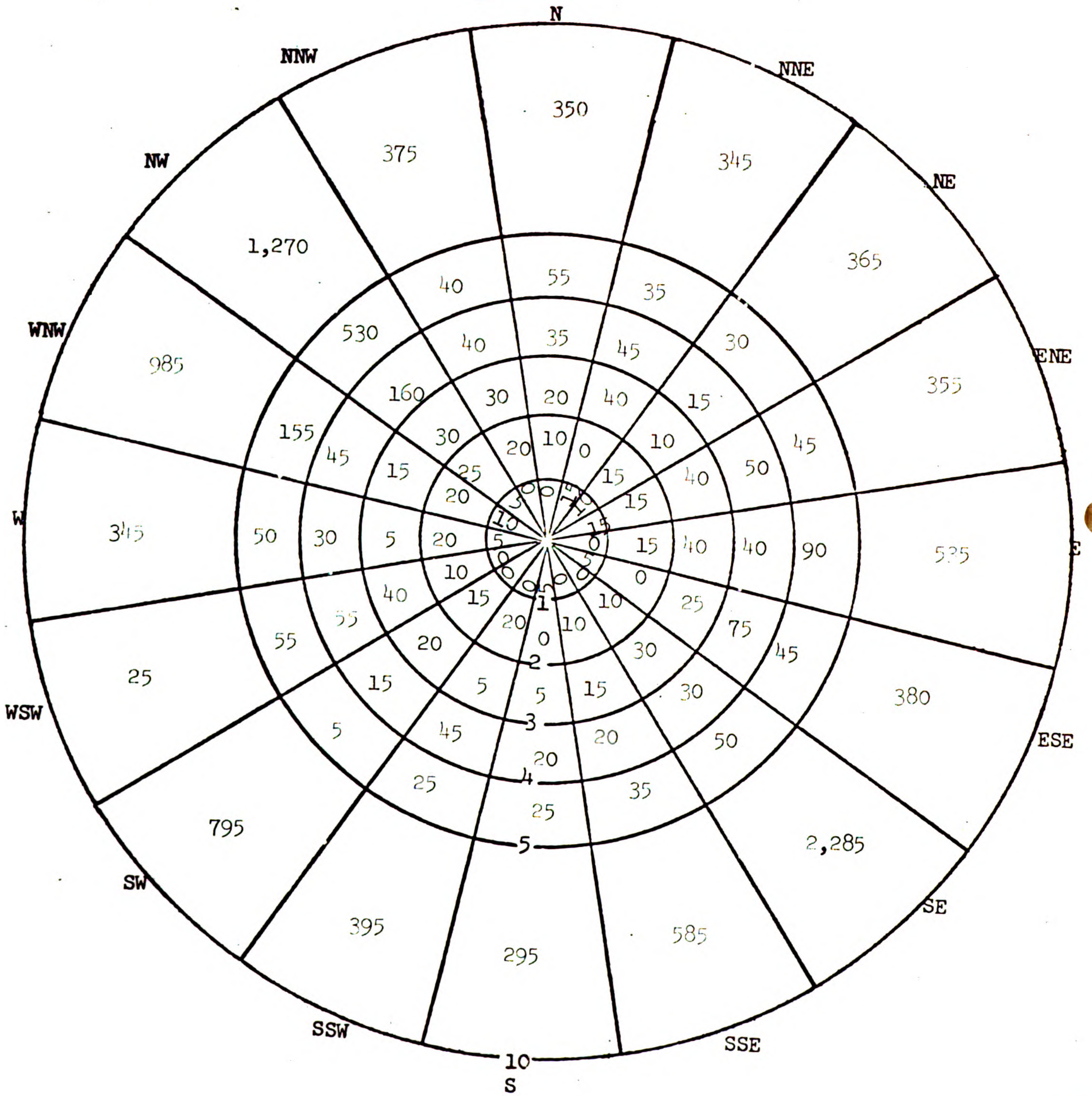

Figure 9.3-3

POPULATION DISTRIBUTION
HARTSVILLE SITE
Year 1970

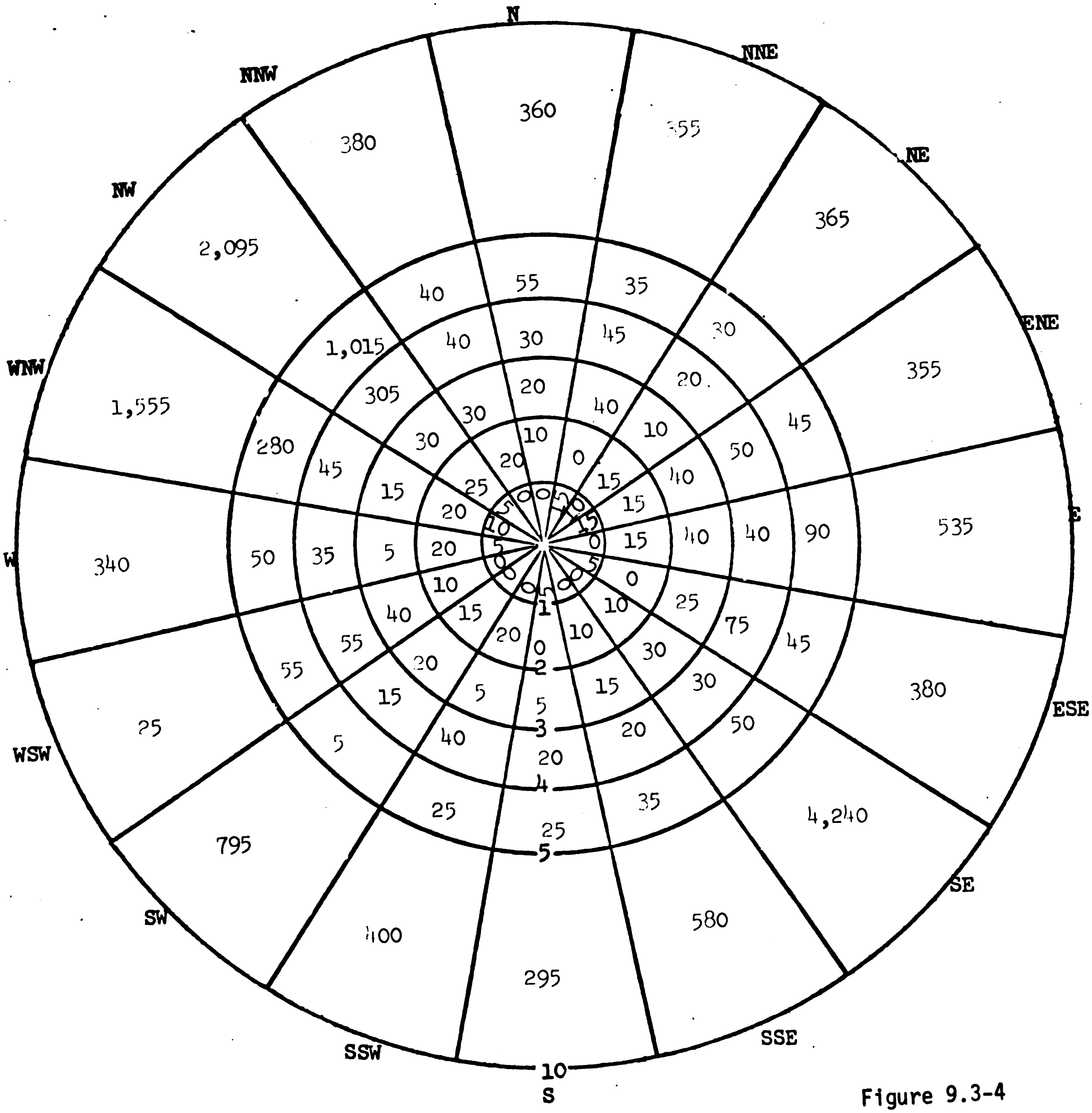

Figure 9.3-4

POPULATION DISTRIBUTION
HARTSVILLE SITE
Year 2000

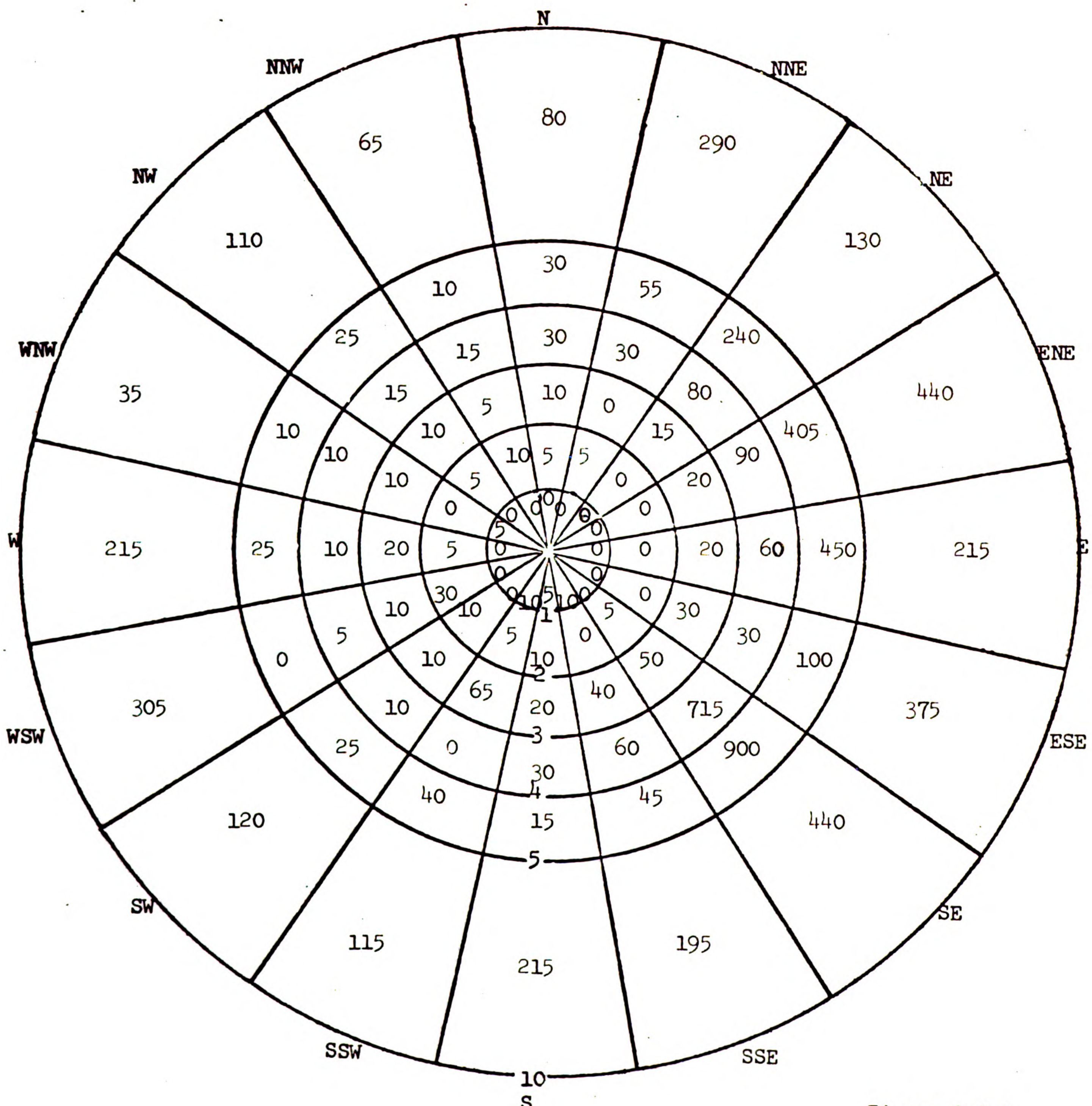

Figure 9.3-5

POPULATION DISTRIBUTION
COUNCIL BEND SITE
Year 1970

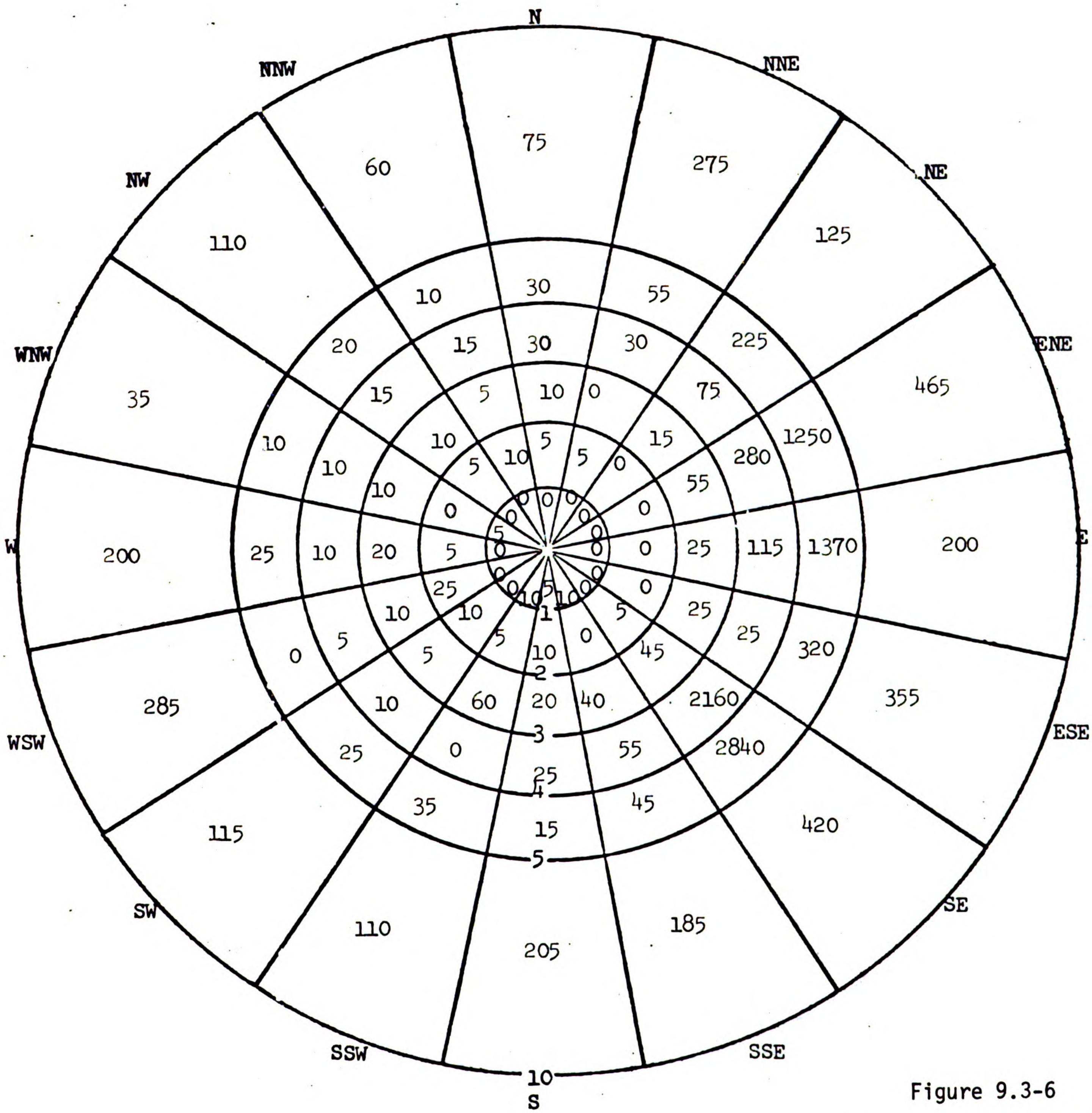

Figure 9.3-6

POPULATION DISTRIBUTION
COUNCIL BEND SITE
Year 2000

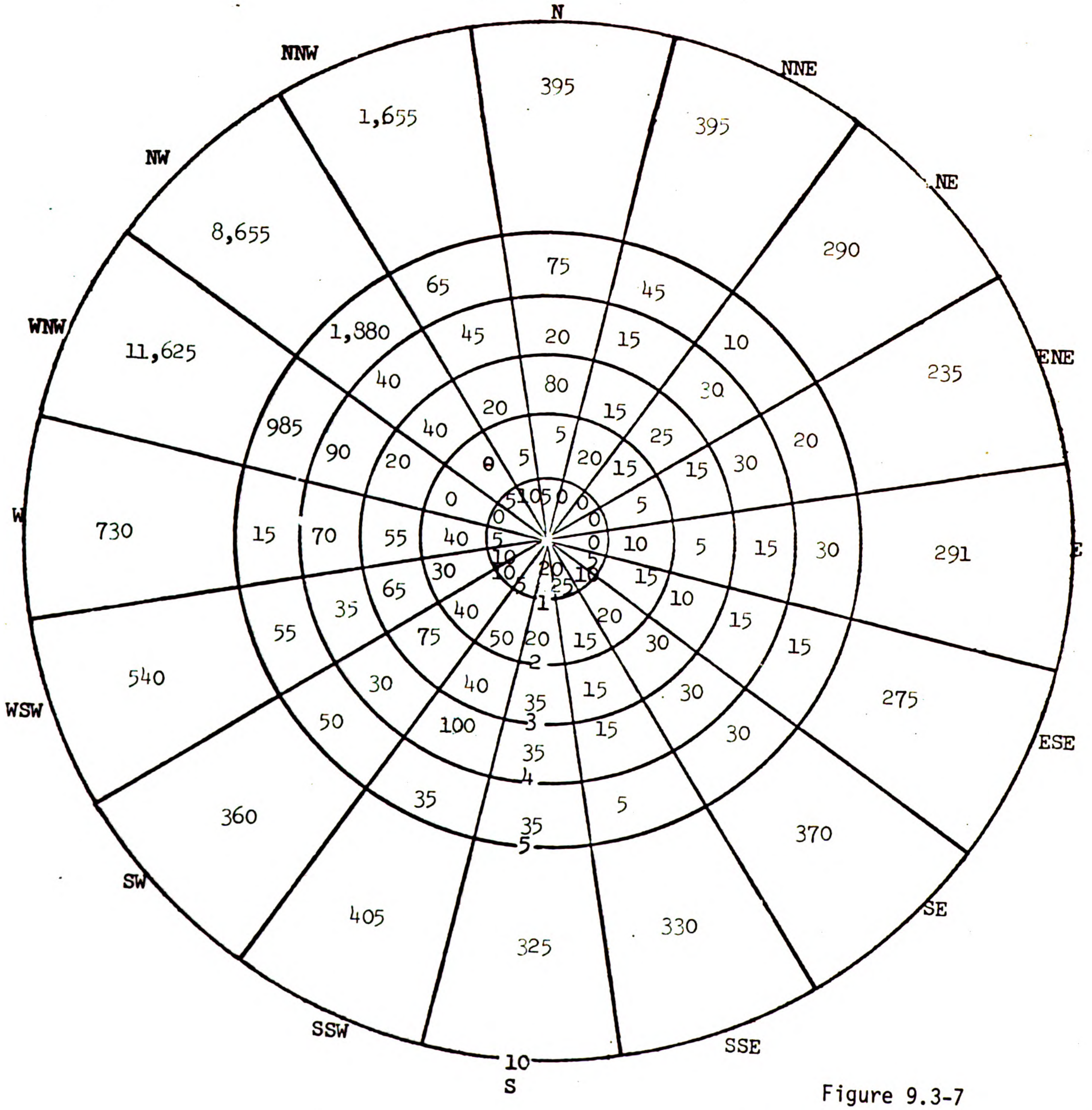

Figure 9.3-7

POPULATION DISTRIBUTION
RIEVES BEND SITE
Year 1970

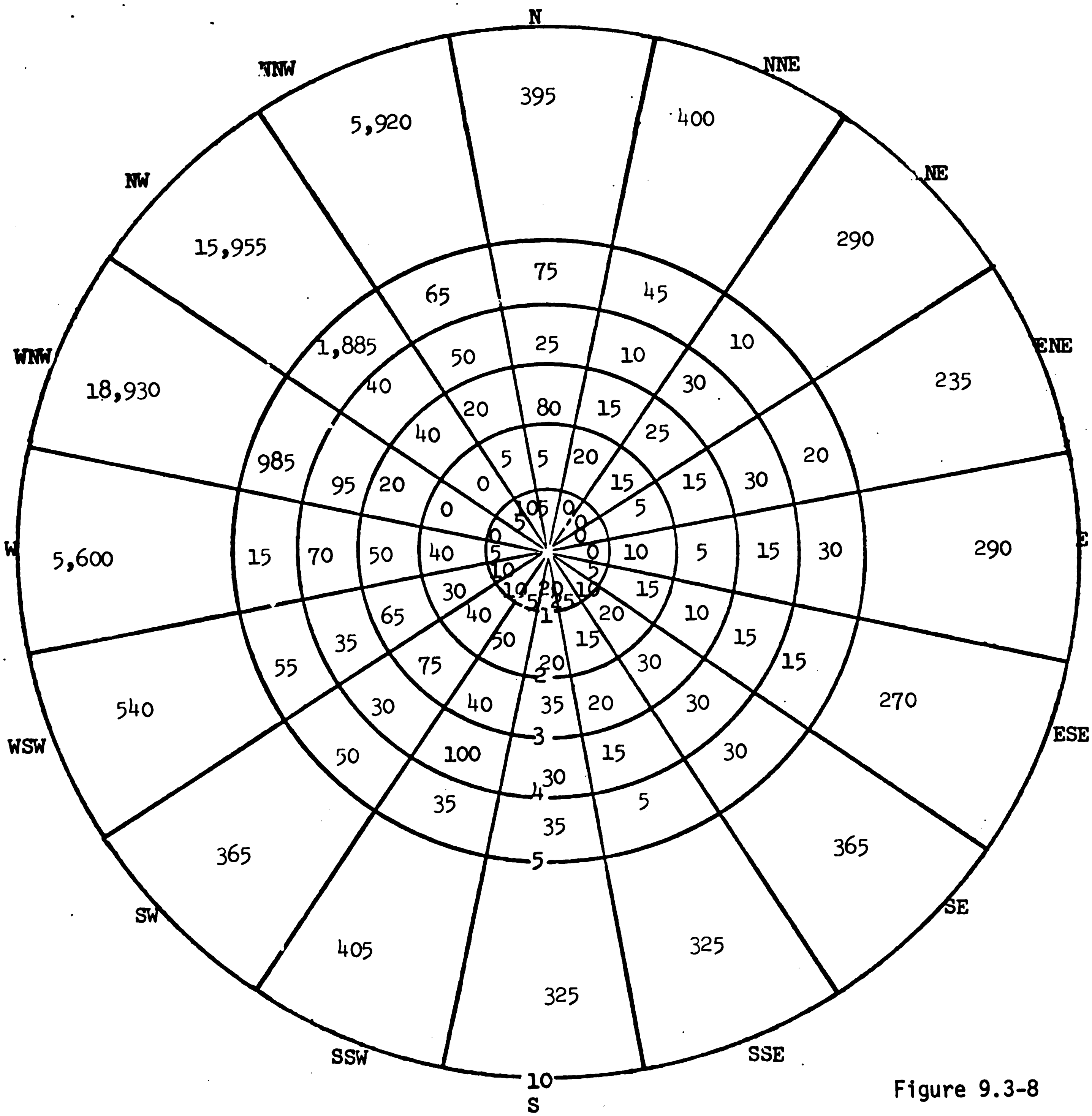

Figure 9.3-8

POPULATION DISTRIBUTION
RIEVES BEND SITE
Year 2000

COMPARISON OF POPULATION INCLUDED IN VARIOUS RADII

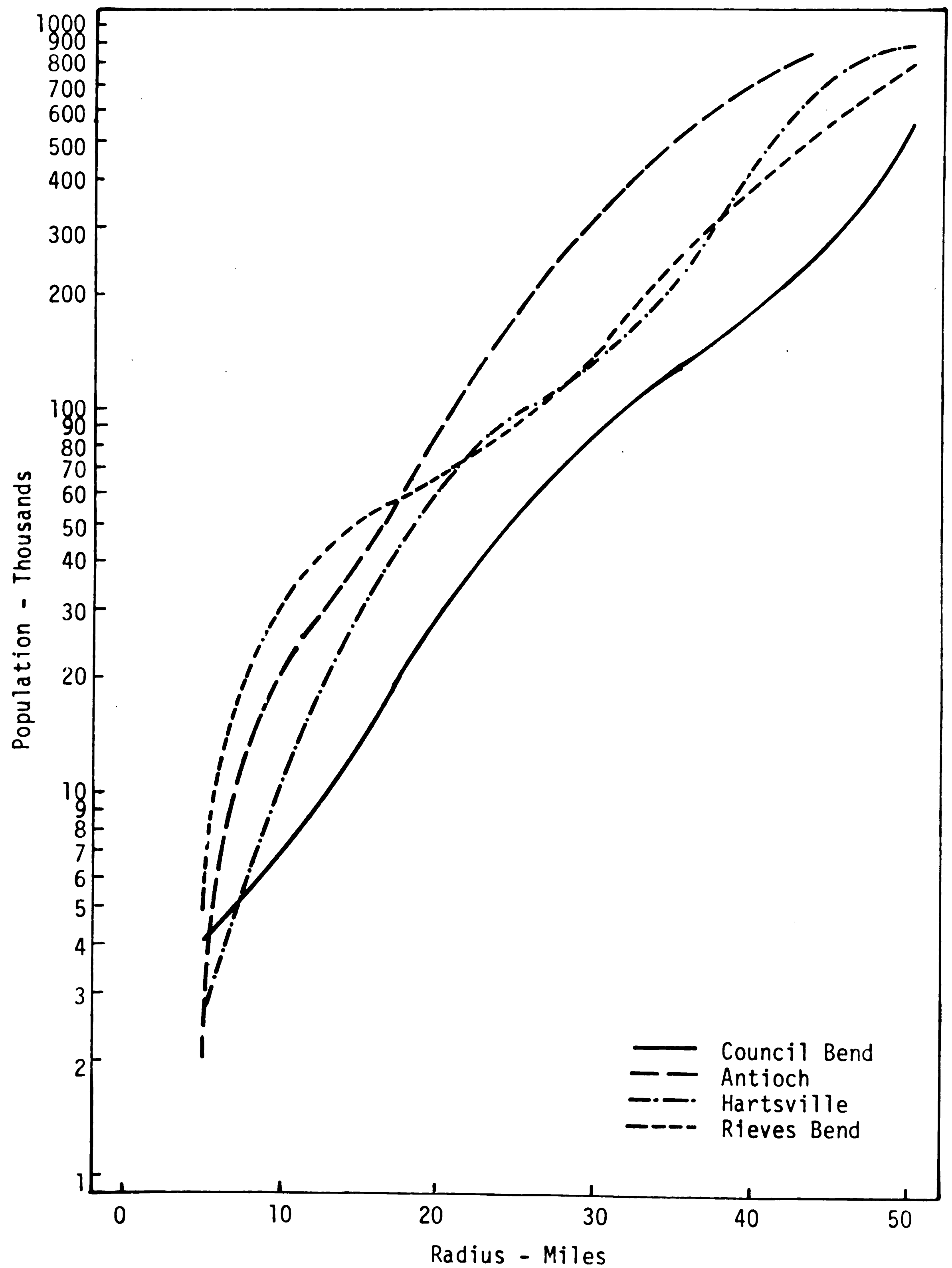

Figure 9.3-9

POPULATION DISTRIBUTION
VARIOUS RADII

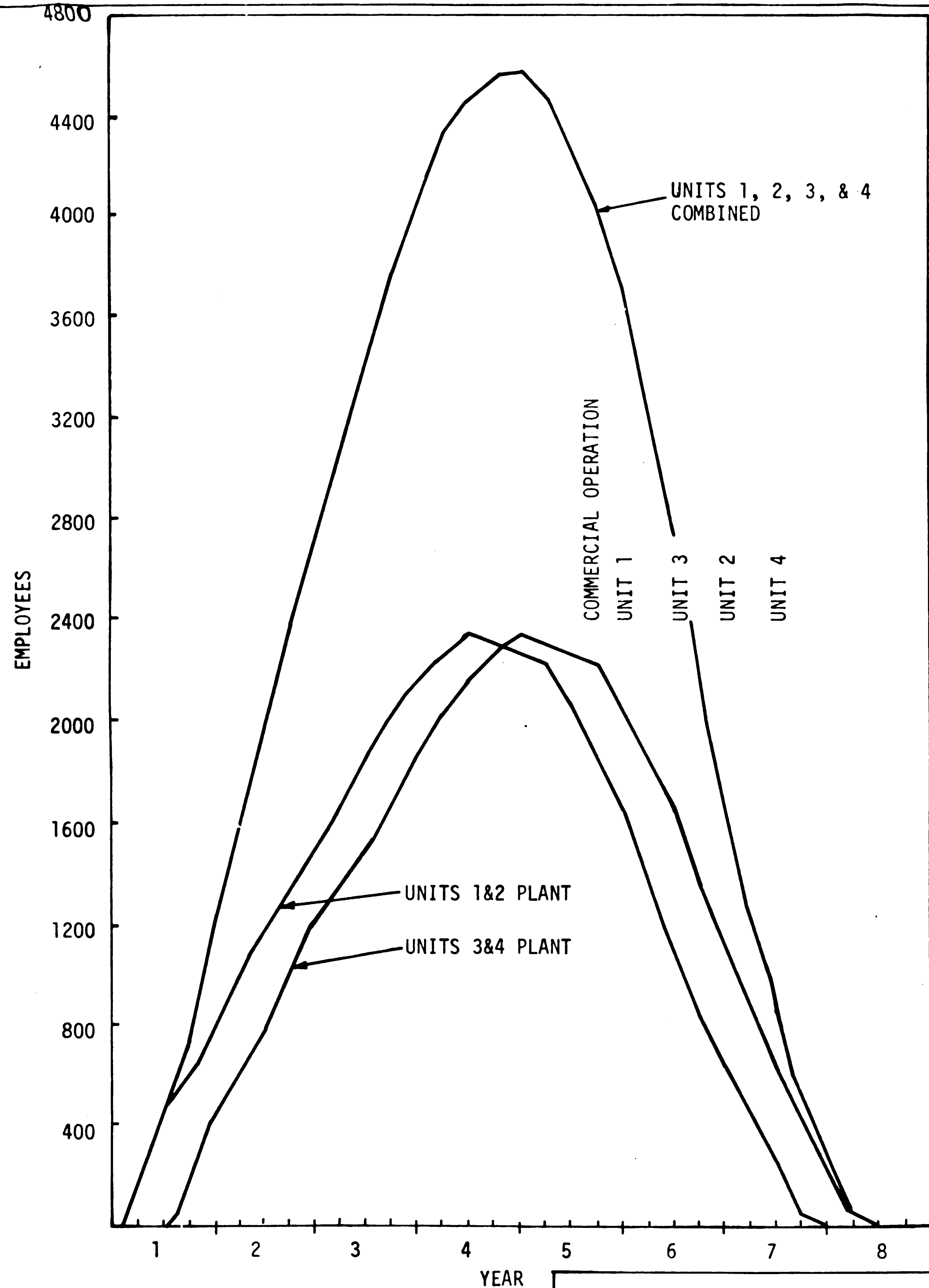

Figure 9.3-10

MANPOWER ESTIMATES FOR TWO 2-UNIT NUCLEAR PLANTS AT COMMON SITE

10.0 Evaluation of Alternatives for Plant Systems

In order to minimize the impacts to the environment of the Hartsville plant, care was taken to select proposed systems for the plant which give the maximum protection to the environment which can reasonably be provided. To ensure this, systems which had potential adverse environmental effects were submitted to the analysis which balanced the economic costs against the reduction in environmental impacts. This approach followed closely the procedures set out in the AEC Regulatory Guide 4.2 for selection of subsystems for nuclear power generating facilities. Maximum use was made of various organizations within TVA to assure an integrated interdisciplinary approach in the selection of the optimum systems.

This chapter describes the environmental, economic, technical, and other factors considered in the selection of the proposed systems to assure adequate reliability and environmental protection at the most reasonable cost. The systems which were subjected to these analyses, along with the corresponding sections of this chapter which deal with each system, are shown below.

10.1 Heat Dissipation

10.2 Cooling Tower Blowdown Treatment

10.3 Water Makeup Plant Demineralizer Spent Regenerant Treatment

10.4 Filter Plant Sludge Treatment

10.5 Biocide Treatment System

10.6 Sanitary Waste Systems

10.7 Liquid Radioactive Waste Treatment

10.8 Gaseous Radioactive Waste Treatment

10.9 Plant Water Intake System

10.10 Plant Liquid Discharge System

10.11 Transmission Line Routes

10.12 Access Railroad

The introductory paragraphs of these subsections contain summary descriptions of the rationale employed in the selection of the proposed system. The remainder of each subsection contains detailed descriptions of the alternative systems considered, their relative environmental impacts, and the detailed benefit/cost information used in the selection analysis. A typical organization of a section dealing with an alternative system would be as follows.

10.1 Heat Dissipation Alternatives

10.1.1 Rationale for Selection of Proposed Heat Dissipation System Alternatives

10.1.2 Description of Alternative Designs Considered in Addition to the Proposed System

10.1.3 Evaluation of the Environmental Impact of the Alternative Designs

The benefit/cost information is given, first in detailed narrative discussion and then summarized in tabular form. The organization of the discussions and tables closely follow the organization set out in Tables 3 and 4 of the AEC Regulatory Guide 4.2. Discussion subsection numbers correspond to numbering in the tables for that section (e.g., subsection 10.1.3.1.1 would correspond to section 1.1 in the tables for section 10.1). In

most cases, the method of analysis and units of measure of impacts are as described in the guide. In cases where other units and methods of analyses are used, these are identified.

10.1

10.1 Heat Dissipation Systems

10.1.1 Rationale for Selection - The flow in the Cumberland River at the proposed plant site is frequently too small to permit open-mode cooling for four nuclear units within the current environmental temperature limits of 86.9° F. maximum and 5.4° F. rise. Alternatives considered were natural draft wet towers, mechanical draft wet towers, spray canals, cooling lakes, and mechanical draft wet/dry towers. In addition, other alternatives were investigated but were found to be infeasible.

The natural draft wet cooling towers were selected as the optimum system balancing the economic costs and reduction in environmental impact. Details of this design are given in Section 3.4. Natural draft wet cooling towers are less expensive than spray canals, cooling ponds, or wet/dry mechanical towers. The cooling lake is eliminated because of the cost, the large amount of land required, the loss of several historic sites, and potential ground fog problems. The wet/dry towers are considered unfavorable because of high cost and the limited reduction in environmental impacts. The spray canal is considered unfavorable because of costs, relatively large land use effects, lack of significant improvement in environmental impacts, and aesthetic undesirability.

Mechanical draft wet towers are approximately $10 million less expensive than the natural draft towers. The mechanical draft towers, however, have larger land use effects; and the towers are considered aesthetically unfavorable. The largest factor, however, which influences the choice of the proposed system is potential for fogging and icing.

A TVA study showed that the mechanical draft towers could potentially induce ground fogs which would affect land transportation approximately 1,695 hours per year when considering the five most likely hours of fogging each day, while natural draft towers would essentially eliminate such fogging. The additional cost of natural draft towers is considered to be more than offset by their associated reduction in fogging potential. Moreover, land use effects for natural draft towers are lower than for any alternative considered.

10.1.2 Alternative Designs - In addition to the natural draft towers described in Section 3.4, the following alternatives were evaluated. Some additional performance, design, and cost data are included in Tables 10.1-1 through 10.1-5 for comparison.

10.1.2.1 Mechanical Draft Wet Towers - The mechanical draft wet tower system studied employs a total of eight wet-only towers. The towers are arranged as shown in Figure 10.1-1. Each tower has 14 cells and is about 600 feet long, 70 feet wide, and 70 feet high. Each cell has a fan powered by a 200-horsepower motor. The towers are separated by about 600 feet in both length and width and are oriented parallel to the prevailing summer wind, which is from the south-southwest, in order to minimize recirculation through towers.

Cooling in mechanical draft towers is achieved by the same mechanisms as were described in Section 3.4 for natural draft wet towers except that the air flow is forced by the mechanical fans rather than the induced natural draft. The heat transfer process is identical to the natural draft towers. Mechanical towers consume amounts of water

comparable to the natural draft towers due to evaporation and drift. The mechanical towers develop plumes similar to natural draft wet towers but form the plumes much closer to the ground thereby increasing the chances of their reaching the ground and causing an impact on the neighboring environment.

The mechanical towers require a significant amount of power to operate resulting in high operation costs. These costs are offset somewhat, however, in that in the mechanical towers the air flow is regulated by the fans and not by environmental conditions. This would allow more efficient cooling under many conditions which would result in lower backpressures on turbines and higher turbine generator output than the natural draft towers. Mechanical towers are a proven and reliable means of effective heat dissipation.

<u>10.1.2.2 Cooling Lake</u> - Topography at the Hartsville site is not suitable for construction of a lake which is large enough to dissipate all of the waste heat from this 4-unit plant. Some additional means of heat dissipation is required. This scheme uses a 4,200-acre lake supplemented by a spray canal, as shown on Figure 10.1-2. The lake is formed by construction of a dike about 4,000 feet long on Wilburn Creek and a dike about 6,000 feet long on Dixon Creek. Another dike about 8,000 feet long is located 500 feet **south** of the first dike on Dixon Creek. These two dikes form a channel which contains about 225 spray modules. Normal water surface elevation is 520 feet. Hot water from the plants would discharge into the lake just north of the dikes on Dixon Creek. It flows clockwise around the island in the center of the lake, then passes through the channel containing spray modules before

reentering the plant. During floods, excess water leaves the lake by flowing over the dike on Wilburn Creek and into the Cumberland River. Circulation time through the lake is on the order of 10 days. There is no drift from a cooling lake; however, there would be some drift from the spray modules.

The cooling lake dissipates heat from the condenser cooling water to the atmosphere by the natural processes of convection, radiation, and evaporation. A relatively large lake surface area is required to provide adequate air-water contact. At the Hartsville site the lake would be supplemented by spray modules to provide adequate heat dissipation capability. The warm water is sprayed into the air where the interaction with the air acts in the same manner as the water-air contact in cooling towers with convection and evaporation providing the cooling mechanism. This alternative would have a greater amount of evaporative water loss than the tower schemes because the solar heat added to the lake must also be dissipated. Evaporation from the lake and spray modules would give a high probability of ground fog problems in the area.

The cooling lake with spray canal is considered to be a reliable and proven method for effective heat dissipation.

10.1.2.3 Spray Canal - This scheme would require a total of about 702 spray modules in a spray canal laid out as shown on Figure 10.1.3. The canal would be about 19,000 feet long. Normal water surface in the canal would be at elevation 482. Width of the canal would be about 280 feet at the water surface expect for a section of the canal which does not contain spray modules. This section of the canal would

lie just east of the plants and would be about 170 feet wide at the water surface.

The configuration of the spray modules varies among manufacturers. The layout studies is based upon a module having four spray nozzles in line, with a 40-foot-diameter spray pattern for each nozzle. Each module thus requires a space 160 feet long by 40 feet wide. The modules are arranged six abreast in the canal, with 160 feet of canal length required for each row of six modules.

Cooling for this scheme is acocmplished in the same manner as the previously mentioned cooling lake with spray canal. In the canal scheme, however, more cooling is accomplished through use of the spray modules than through the surface effects on the canal. In this way, the necessary surface area required for the lake is reduced, allowing a much smaller area to be utilized. Because of the increased use of the spray and the warm moist air plume, the drift loss is greater than that associated with the large lake.

10.1.2.4 Wet/Dry Cooling Towers - Mechanical draft, wet/dry cooling towers are very much like conventional, all wet mechanical draft towers except that each cell has a dry surface heat exchanger along with the wet fill. (Details vary with different manufacturers.) The dry surface section causes air to leave the tower at lower relative humidity than with an all wet tower, thus reducing both the frequency and the intensity of plumes and ground fog.

This system is comparable to the all wet mechanical draft tower scheme in the number and size of towers, range, and circulating water flow. Total evaporation is also comparable to the all wet towers except when the dry sections are in use, in which case evaporation will be lower.

Costs of wet/dry towers are much greater than all wet mechanical draft cooling towers (for the same cooling capability) so the optimum design is to have smaller towers, with higher net turbine heat rate, lower net turbine output, and lower auxiliary power than the optimum all wet tower design. Consequently, costs for facilities, operation, and capacity replacement are all higher than for all wet towers.

10.1.2.5 Other Schemes Considered - The following schemes were considered but were not evaluated through the total benefit/cost analysis because they were found to be infeasible for economic or engineering reasons early in the evaluation process. A discussion of each is given below.

10.1.2.5.1 Dry Natural Draft Towers - Natural draft dry cooling towers would be comparable in size to the natural draft wet towers described in Section 10.1.1. However, more than one tower would be required for each unit. Dry towers dissipate heat to the atmosphere by conduction and convection. Heated cooling water flows through banks of finned-tube heat exchangers. Air flows up past the finned tubes. Heat from the water is transferred through the metal by conduction and then into the air by convection. The heated air rises from the tower and the cooler air beneath it replaces it, creating the "natural draft" of cooling air. Advantages of the towers would be: (1) no blowdown, (2) no problems of drift and its effect on the neighboring environment, (3) no evaporation or fogging problems, and (4) no makeup required except for small leaks.

Although dry towers have been used in European power plants for some time on units of the 200-MW size and smaller, they have never been employed on any nuclear plant of comparable size to the Hartsville plant. Many of the small fossil power plants which have used dry towers have experienced potentially serious operating problems. Heat exchanger tube freezing has been reported at the Rugeley Station in England, the Ibbenbüren Plant in West Germany, and at the Gyöngyös Station in Hungary.[1] A serious air-side corrosion problem was reported at the Rugeley Station.[1] Serious questions have also been raised concerning tube-side water chemistry.

The higher backpressure (5- to 18-inch Hg absolute) installation present problems with the larger last-stage buckets and larger exhaust hood structures of the large nuclear turbines. The design problems which must be considered by the turbine manufacturers for turbines for dry cooling tower application are: possible overheating of the last-stage buckets, possible flutter damage to the last-stage buckets at high-exhaust pressure and low loads, rapid exhaust temperature changes due to load changes which cause cycling thermal stresses, distortion of the exhaust hood and bearing supports, and difficulty in providing adequate clearance control.

The use of these towers with nuclear plants brings out other problems not solved at this time. To date, dry towers have not been used in connection with nuclear plants where safety might be a factor.

Dry cooling towers also present environmental effects about which little is known at this time. Operational experience for dry towers is not adequate to define these problems.

The application of dry towers to large nuclear units constitutes a tremendous commitment of capital resources. To stay within all design constraints of the system, sixteen 410-foot-diameter by 500-foot-high natural draft towers would be required for this station. The incremental cost difference between dry and wet cooling towers in the southeastern section of the U.S. is on the order of 1 mill/kWh.[2] No commitment of this size to dry cooling towers has ever been undertaken and is, in our opinion, beyond the present state of the art. It is TVA's best engineering judgment, considering cost penalty and technical obstacles versus above-mentioned advantages, that dry cooling towers are not feasible for this plant.

10.1.2.5.2 Once-Through Cooling - Once-through cooling utilizing a diffuser discharge to the reservoir has been a practical consideration at other plant sites in order to benefit the plant with cooler water for condenser cooling which results in improved efficiency due to lower turbine backpressure and corresponding increased plant capability. Because of the Tennessee thermal water quality standards of 5.4° F. rise and 86.9° F. maximum, the completely open system is not considered feasible for this plant. Assuming the heated effluent is mixed with 75 percent of the riverflow, a riverflow of about 35,700 ft^3/s would be required to maintain a 5.4° F. river rise with all four units operating at full load. Since the average riverflow at the site has been about 17,000 ft^3/s, a once-through cooling system would require serious curtailment of plant generation a substantial part of the time in order to avoid exceeding the 5.4° F. maximum rise. Consequently, a once-through cooling system cannot be considered feasible for providing a reliable source of power while meeting thermal criteria at the Hartsville site.

10.1.2.5.3 Combined-Cycle Systems - Combined-cycle systems are capable of operating in any of the three modes as required:

(1) Open Mode - Operates as a once-through system with heat dissipated to the river.

(2) Helper or Topping Mode - Heated condenser water is circulated through a supplemental cooling facility for initial cooling and then discharged to the river.

(3) Closed Mode - Operates in a closed loop with heat dissipated to atmosphere by, for example, a tower.

Combined-cycle systems usually have the advantages of low inlet water temperature and low operating cost while in the open mode and low inlet water temperature while in the helper mode. However, at the Hartsville site, in order to locate the plant for flood protection, water must be pumped a distance of about 3,000 feet with an increased elevation of 100 feet to the plant. This pumping head greatly reduced the attractiveness of open- and helper-mode operation at this site because of the much larger costs which could be encountered for the additional pumping requirements, intake and discharge facilities, etc. Also, as discussed in Section 10.1.2.5.2, once-through cooling would often fail to satisfy thermal criteria unless plant generation were reduced. Consequently, a combined-cycle system would have to operate in either helper or closed modes a large percentage of the time, reducing the economic advantages of the combined cycle.

For these reasons, TVA decided that no further investigation of combined-cycle systems is justified for the Hartsville plant.

10.1.3 Impact Assessment of the Alternative Designs

10.1.3.1 Surface Waters

10.1.3.1.1 Impingement or Entrapment by the Intake Structure - The amount of fish entrapped or impinged at the cooling water intake structure is thought to be dependent upon the design and location of the intake structure. Since makeup requirements for all of the viable heat dissipation alternatives are very similar (± 16 percent of proposed), intake designs and location for any alternative heat dissipation scheme considered would be basically the same. Consequently, it is expected that no significant differences would exist in impingement or entrapment of fish for the different cooling alternatives.

The table shows the relative flow requirements of the alternatives.

Alternative Scheme

	(1) Mechanical Draft Towers	(2) Cooling Lake	(3) Spray Canal	(4) Wet/Dry Mechanical Draft Towers
Makeup (gpm)	100,000	116,000	104,000	84,000
Makeup, Percent of Proposed System	100	116	104	84

10.1.3.1.2 Passage Through or Retention in the Cooling System - All biota taken into the cooling system with the makeup water are considered to be killed due to the mechanical action of the pumps and by the thermal shock of passing through the condenser.

10.1.3.1.2.1 Phytoplankton and Zooplankton - It is assumed that the number of plankton affected by the alternatives is proportional to the makeup water requirements of the system. The relative amounts of plankton which would be destroyed by the various cooling systems analyzed are as follows.

Scheme	Percent of Proposed System
1. Mechanical draft towers	100
2. Cooling lake	116
3. Spray canal	104
4. Mechanical wet/dry towers	84

Numbers and distribution of species which would be affected are as discussed in Section 2.7 and in Appendix F2. Although slight differences can be predicted for the various alternatives, the overall impact for any alternative is judged to be insignificant.

10.1.3.1.2.2 Fish - The larval fish which would be entrained in the makeup to the heat dissipation system are assumed to be killed. It can be assumed, however, that in nature a 90 percent mortality rate occurs during the larval fish stage. The amounts of larval fish entrained in the makeup and subsequently killed may be assumed to be proportional to the respective makeup rates for the alternative systems. Using this assumption, estimated relative amounts of larval fish taken in are shown as follows.

	Alternative Scheme	Percent of Proposed System Makeup	Entrained Larvae/Year
1.	Mechanical draft towers	100	16.0×10^6
2.	Cooling lake	116	18.6×10^6
3.	Spray canal	104	16.6×10^6
4.	Mechanical wet/dry towers	84	13.4×10^6

Although the differences in impacts of the alternative heat dissipation systems may be mathematically predicted, it is considered that the difference in the overall impact on the fish population in the reservoir would not be measurable.

10.1.3.1.3 Discharge Area and Plume - The heat dissipation systems analyzed are expected to normally operate at a solids concentration of twice that occurring in the river. In order to maintain this level, an amount of water approximately equal to the amount of water which evaporates from the system must be discharged as blowdown. This blowdown would be the major discharge from the plant diffuser.

All alternatives considered would cause thermal plumes of similar size and shape. This, plus the fact that blowdown could be withheld during periods of low river flow, would result in only very minor differences in thermal discharge effects for any of the heat dissipation alternatives. A discussion of the shape and effects of the discharge and plume for the proposed system is given in Section 5.1. The overall effects due to thermal discharges of the different heat dissipation alternatives are not considered to be significant.

Dissolved oxygen concentrations in the blowdown will be at their lowest levels during periods of maximum blowdown temperature.

It is assumed that the concentration of dissolved oxygen in the blowdown will be at or near the maximum solubility for the temperature of the blowdown. Listed below are the heat dissipation alternatives considered, their maximum blowdown temperatures, solubilities of dissolved oxygen at these expected temperatures (based on an elevation of 445 feet MSL) and dissolved oxygen concentrations representing 80 percent of the solubility value.

Heat Dissipation Alternative	Maximum Mean Monthly Blowdown Temperature	Dissolved Oxygen Solubility	80% of Dissolved Oxygen Solubility
	°F	mg/l	mg/l
1. Proposed natural draft wet towers	85.1	7.5	6.0
2. Mechanical draft wet towers	90.7	7.2	5.8
3. Spray canal	91.8	7.1	5.7
4. Cooling lake with spray modules	91.8	7.1	5.7
5. Mechanical draft wet/dry towers	89.8	7.2	5.8

It can be seen that, at dissolved oxygen concentrations of saturation and 80 percent of saturation for maximum blowdown temperatures, the dissolved oxygen concentration of the blowdown will not be less than 5.0 mg/l for any of the heat dissipation alternatives. Therefore, the volume of affected waters with dissolved oxygen concentrations below 5, 3, and 1 ppm will be zero, regardless of heat dissipation system.

10.1.3.1.4 Chemical Effluents - It is expected that all heat dissipation alternatives would be operated at a concentration factor for total solids of about two as discussed previously. Therefore,

the only differences in the effects of the chemical effluents from any of the alternatives would be associated with the differences in the amounts of water discharged. Since the maximum blowdown rate for any alternative differs by only about 16 percent from that required for the proposed system, no significant differences in effects on physical or biological water quality due to chemical effluents would be expected.

10.1.3.1.5 Radionuclides Discharged to Water Body - The choice of cooling system alternative is not judged to have any effect on this impact other than a difference in dilution rate of about 16 percent as related to blowdown requirements.

10.1.3.1.6 Consumptive Use - Total consumptive use attributable to each cooling alternative is that system's evaporative loss plus losses due to drift. When the amount of evaporative losses for the alternate cooling systems considered are compared with the average annual Cumberland River flow of 17,000 ft^3/s[a], they comprise the following percentages.

Evaporative Loss as a Percentage of Annual Cumberland River Flow

Natural Draft Cooling Towers	Mechanical Draft Cooling Towers	Spray Canal	Lake With Spray Canal	Wet/Dry Cooling Towers
0.7	0.7	0.7	0.8	0.6

Since average consumption by public utilities from Old Hickory Reservoir is approximately 10 ft^3/s, or 0.06 percent of the average annual Cumberland River flow, the loss of water due to

a. Measured at USGS gage at Carthage, Tennessee, at CRM 308.2, for period of record 1951-1971 (does not include regulation of flows by Cordell Hull Dam)

evaporation and drift will be insignificant to public water users. All public water needs can be easily met by the existing supply, and no additional delivery costs for replacement water will be realized. Therefore, the use of water for agricultural, industrial, and domestic purposes would not be affected by use of any of the heat dissipation alternatives.

10.1.3.1.7 Plant Construction - The effects on the surface waters due to construction of any of the heat dissipation alternatives are dependent primarily upon the amount of land which is disturbed and hence the amount of erosion which occurs because of this disturbance. Erosion would potentially increase the concentration of solids, etc., in the water of the reservoir. The amounts of land disturbed for the various alternatives and the corresponding quantities of runoff which could result from the maximum predicted one-hour, 5-year storm are shown below.

Alternative	Construction Area	1-Hour, 5-Year Storm Estimated Runoff
	Acres	Acre-Feet
Natural draft cooling towers	62	4.8
Mechanical draft cooling towers	96	7.4
Spray augmented cooling lake	4,300	330.0
Spray canal	250	19.3
Wet/dry towers	96	7.4

Experience at other TVA construction projects where similar control techniques are used indicates runoff would contain less than 10,000 mg/l suspended solids.

The State of Tennessee does not have a stream limit for turbidity but does have an effluent guide. Since the reservoir is the only available source of dilution water available, it is not practicable or desirable to dilute the runoff in order to meet the effluent guideline. At various times of the year, particularly during rainy seasons, the turbidity in the reservoir exceeds the limit so that runoff diluted with reservoir water would not meet the limit regardless of dilution quantity used. Therefore, no dilution would be utilized for any alternative.

10.1.3.1.8 Other Effects

10.1.3.1.8.1 Alteration of Dixon Creek - The spray canal scheme would require significant alteration of Dixon Creek which would result in the destruction of significant aquatic and riparian habitat.

10.1.3.1.8.2 Impoundment of Surface Water Bodies - The cooling lake scheme would impound Dixon Creek and some smaller creeks. The natural creek and terrestrial areas would be destroyed, but the lake would create 4,300 acres of new habitat for aquatic forms. The net effects of this change in habitat cannot be quantified.

10.1.3.2 Alternative Effects on Ground Water - The only effects which might result from any of the heat dissipation alternatives would be the raising or lowering of the ground water levels. The spray canal scheme and the cooling lake could slightly raise ground water levels in the area but it is not expected that the effect would be significant.

The systems would basically contain only reservoir water and seepage into ground water supplies would not result in contamination severe enough to affect usage.

The general slope of the ground water table in the area around the proposed plant is toward Old Hickory Reservoir. Therefore, any alternative in the area of the plant such as the cooling tower schemes could affect only the ground water between the plant and the reservoir. Since there will be no wells or other uses of ground water between the plant area and the reservoir, no ground water uses would be affected by these alternatives.

<u>10.1.3.3 Effects Related to Meteorology</u> - The alternative schemes considered for heat dissipation were evaluated for potential fogging and icing effects. A discussion of the model used for these evaluations is presented in Section 5.1.6. Additional details for the models which were used are as follows.

a. For the mechanical draft wet and wet/dry towers, the 200- and 400-foot absolute humidity deficit values were calculated from interpolated Nashville rawinsonde dry-bulb temperature and dew point data and then averaged for the layer. The onsite 150-foot wind direction data were used to determine the plume directions.

b. For the natural draft (wet) towers plume length and direction calculations, only the Nashville rawinsonde data were used. Nine absolute humidity deficit values were calculated from interpolated values of dry-bulb

temperature and dew point at 200-foot intervals from 400 to 2,000 feet aboveground and averaged to obtain the mean absolute humidity deficit for the layer. The corresponding nine wind direction values for the layer were averaged to give the estimated plume direction.

c. Spray canal plume lengths were calculated with absolute humidity deficit values calculated from Nashville rawinsonde surface dry-bulb temperature and dew point data. Plume directions were determined from the onsite 33-foot (10-meter) wind direction data.

d. Each cooling tower alternative and the spray canal alternative were treated as a point source of water vapor; and each source was assumed to be near the center of the plant site, except for the spray canal associated with the cooling lake. This spray canal would extend about 2 miles southeast of the reactor sites. Therefore, the plume point source was assumed to be about 1 mile southeast of the reactor sites.

e. For each of the mechanical draft towers, spray canal, and cooling lake with spray canal alternatives, overlap of hours of fogging over the river due to both the blowdown discharge and the presence of the visible vapor plume was accounted for in the evaluation of the potential impact on river traffic. According to the U.S. Army Corps of Engineers, there is presently no regular commercial river traffic passing the Hartsville site.[3] Therefore, the estimates refer to the expected hours per year that future

river traffic might be affected by fogging from the operation of each of the heat dissipation alternatives.

f. The fogging and icing effects from the cooling lake were assessed by modifying the percent occurrence of fog over the lake surface predicted by the river fogging model. The predicted percentage was based on the Gallatin meteorological data for the period April 1972-March 1973 and estimated average monthly lake surface temperatures. State highway 25 would cross the heated lake along its present right of way. The road and bridge surfaces would range from 7 to 12 feet above the lake surface. In modifying the river fogging model prediction of steam fog over the cooling lake, the stability and wind speed patterns at the Hartsville onsite meteorological facility were considered for estimating the height and thickness of the fog layer relative to the highway.

10.1.3.3.1 Icing Effects - Rime icing associated with plumes or steam fog for any alternative considered is not expected to present any significant problem except occasionally on plant structures and on highway 25, especially on bridges where they would cross the cooling lake. The rime ice would be comparable to the feathery "frost" seen on trees during natural fog episodes with subfreezing temperatures. For any alternative considered, little or no formation of the rime would be expected on road surfaces in the vicinity of the plant, except possibly highway 25 as noted above.

Drift from the alternatives could cause glaze icing. However, drift would be kept to a minimum by drift eliminators, etc.,

and most of the drift which leaves the source would reach the ground or other surfaces within 1,000 feet. Accumulation of glaze ice would therefore be limited to structures within a few hundred feet. In fact, TVA's experience with the natural draft towers at the Paradise plant indicates that few, if any, drift droplets reach the ground. During infrequent conditions of water vapor saturation of the layer of air from the surface to 500 feet or more, much of the drift that escapes the eliminators might reach the ground. In many such cases, rain would be falling and drift deposition would not be discernible. However, mechanical draft towers would deposit relatively greater amounts of drift on the ground because of the larger drift rate and much shorter towers.

For mechanical draft wet towers, the potential for plume-induced rime icing exists on roads within a 9-mile radius of the Hartsville site, most of this icing would be light and would occur primarily on exposed, vertical surfaces such as trees and buildings. Any accumulation on road surfaces would seldom have any adverse effect on ground transportation. The study indicated, however, that the potential for icing effects on ground transportation could exist for certain roads on 1.3 percent of the total annual days (Figure 10.1.5).

For the spray canal alternative, the potential for effects on ground transportation from plume-induced rime icing is very small. The analysis shows that the potential for such icing could exist on about 2 percent of the annual days for certain roads in the west-southwest sector from the plant site (Figure 10.1.7).

Spray canals would present no glaze ice problem because of the relatively low level (less than 30 feet high) of the spray. In most cases, the drift would fall back into the canal.

For mechanical draft wet/dry towers, the potential for effects on ground transportation from plume-induced rime icing is quite small. The analysis shows that the potential for such icing could exist on 1.3 percent of the total annual days for certain roads (Figure 10.1.11).

For the cooling lake with spray augmentation, the potential for icing effects on ground transportation from rime icing induced by the spray plume is small. However, the potential for icing on the stretch of Tennessee highway 25 spanning the cooling lake is much greater. Rime icing on the road, especially on the bridges over the cooling lake, could be a significant hazard to traffic during periods of subfreezing temperatures. There were only 33 days with temperatures equal to or less than 32° F. at the Hartsville site for the period February 1973-January 1974. However, for the period 1966-1972 there was an annual average of 81 days with 32° F. or less at the Nashville airport.[4]

<u>10.1.3.3.2 Fogging Potential</u> - The potential effects for fogging were evaluated for each of the alternatives. The results of these studies are given below.

<u>10.1.3.3.2.1 Mechanical Draft Wet Cooling Towers - Ground Transportation</u> - The relatively low-level releases (70 feet high) from the mechanical draft towers would cause some ground-level fogging. Calculations indicate that visible plumes, reaching the ground during periods of turbulent mixing, could affect ground transportation on over 300 days per year, with the maximum plume length extending at times out to about 9 miles. Daily plume effects

would normally be most pronounced during the 5-hour period, 0300-0800 LT. Thus, fogging from plumes could affect ground transportation 1,695 hours per year and could involve a traffic volume of 287,350 vehicles annually. On nearly 50 percent of the annual days (or cases), plumes could affect roads in the west-southwest, west, west-northwest, and northwest sectors from the plant site (Figure 10.1-4). Apparently, plumes should least often affect roads in the southeast sector (about 2 percent of the annual days). The most heavily traveled roads within 9 miles are in the community of Hartsville and could be affected on 5-8 percent of the annual days. In the northwest sector, the relatively heavily traveled Tennessee Highway 25 could be affected on about 13 percent of the annual days.

<u>Water Transportation</u> - Mechanical draft tower plumes passing over the river and steam fogging generated by rises of river surface temperature from blowdown discharge could affect river traffic about 957 hours annually. Of the 957 hours, about 497 hours would be attributed to steam fogging and 460 hours to plume effects. Daily plume and steam fogging effects should be most pronounced during the early morning hours, when the naturally occurring radiation or steam fogs are also most pronounced. Effects on river transportation should be most prevalent immediately downstream from the plant site because of the induced steam fogging from the blowdown discharge and over the river 1-5 miles west-southwest through west-northwest of the plant site because of expected relatively high frequencies of visible plumes (Figure 10.1-4).

The annual average frequency of occurrences of heavy fog (1/4 mile visibility or less) observed at the National Weather

Service Station at Nashville was considered in the estimates of hours of potential heavy fogging for each alternative evaluated. This observed frequency resulted in a reduction of 17 days, or cases, per year.[4]

Air Transportation - Analysis of the predicted visible plume behavior shows that maximum plume lengths should be about 9 miles. Since no airports are located within 10 miles of the plant site, no interference with airport operation would be expected.

Plants - No significant injury or adverse effects on vegetation are expected from the daily exposure to excessive moisture because of the relatively short duration (5 hours or less). Also, during the pre- and post-dawn hours the vegetation is normally exposed to naturally occurring high relative humidity and dew. Even though there is a slight possibility that excessive humidity from the mechanical draft tower operation may increase the incidence of plant disease, this effect should be compensated by the growth stimulation provided by the additional moisture released during periods of naturally occurring low relative humidity.

10.1.3.3.2.2 Spray Canal -

Ground Transportation - Very low-level (near ground level) plumes from the spray canal should cause surface fogging which could affect ground and water transportation. Although the fogging potential from spray canal plumes could extend nearly 10 miles from the plant site in some sectors, surface roughness and terrain features such as trees and hills would reduce the plume lengths below predicted values. Fogging from the plumes could affect ground transportation on about 346 days per year for a total of 1,729 hours and could involve a traffic

volume of 231,050 vehicles annually. The largest effect will be in the southwest, west-southwest, and west sectors from the plant site where the plumes could affect ground transportation on roads on about 53 percent of the annual days (Figure 10.1-9). The least effect could be expected in the north, southeast, south-southeast, and south sectors where the plumes are expected in each sector on about 2 percent of the annual days. Heavily traveled roads in the community of Hartsville could be affected on about 5 percent of the annual days. Tennessee highway 25, within the northwest sector, could be affected on about 6 percent of the annual days.

Water Transportation - Spray canal plumes passing over the river and steam fogging generated by rises of river surface temperature from blowdown discharge could affect river traffic about 1,142 hours per year. About 497 hours would be attributed to steam fogging and 645 hours to fogging from the airborne plumes. Effects on river transportation should be most pronounced immediately downstream due to the blowdown discharge and over the river 1 to 5 miles southwest through west of the plant site in the sectors with the highest frequency of spray canal plumes (Figure 10.1-6).

Air Transportation - Analysis of the predicted spray canal visible plume behavior shows that maximum plume lengths should not exceed 10 miles. Since no airports are located within 10 miles of the plant site, no interference with airport operation is expected.

Plants - As with the other heat dissipation alternatives, vegetation should not be significantly affected by spray canal plumes.

10.1.3.3.2.3 Cooling Lake With Spray Canal -

Ground Transportation - Very low-level (near ground level) plumes from the spray canal and steam fogging generated by the warm surface of the cooling lake could affect ground transportation, primarily on Tennessee highway 25, about 5,614 hours per year. The potential for steam fogging exists for any hour of the day, especially over the cooling lake; however, the maximum potential generally exists during the early morning period, 0300-0800 LT. Periods of potential plume fogging over county highway 6295, which follows the opposite river bank in the south through west-southwest sectors from the center of the spray canal, should coincide with periods of steam fogging from the cooling lake affecting Tennessee highway 25. A traffic volume of about 2,150 vehicles per year could be affected by fogging from the spray canal plume, while about 481,850 vehicles per year could be affected by fogging from the cooling lake. County highway 6296 north of the intersection with county highway 6297 would be inundated by the cooling lake. The affected portion of highway 6296 would probably be abandoned since access to Beasleys Bend and the ferry to Rome, Tennessee (south sector), would be provided by highway 6297. Neither the spray canal plume nor the cooling lake steam fog would be expected to affect traffic on highway 7949 northeast from Dixon Springs, which would also be inundated, and the portion of county highway 6290 where it would lie under the upper Dixon Creek arm of the cooling lake.

Water Transportation - Steam fog generated by the cooling lake should not affect water transportation on the Cumberland River. Such fogs should normally dissipate before reaching the riverbank. However, spray canal plumes passing over the river and steam

fogging generated by rises of the river surface temperature from blowdown discharge could affect water transportation 1,057 hours per year. Of the 1,057 hours, about 497 hours would be attributed to steam fogging and 560 hours to fogging from the plumes. Effects on river transportation should be most pronounced immediately downstream due to the blowdown discharge and over the river 0.5 to 1.3 miles west-southwest and west of the center of the spray canal in the sectors with the highest frequency of spray canal plumes (Figure 10.1-8).

<u>Air Transportation</u> - Analysis of the predicted spray canal visible plume behavior shows that maximum plume lengths should be less than 1.5 miles. Since no airports are located within 10 miles of the plant site, no interference with airport operation would be expected.

<u>Plants</u> - As with the other heat dissipation alternatives, no significant or adverse effects on vegetation are expected from the operation of the cooling lake with spray canal.

<u>10.1.3.3.2.4 Mechanical Draft Wet/Dry Cooling Towers</u> -

<u>Ground Transportation</u> - The effects of mechanical draft wet/dry towers on ground and water transportation would be dependent on the manner in which the towers would be operated; that is, the greater proportion of dry cooling operation, the smaller the potential for plume formation.

<u>10.1.3.4 Effects on Land</u> -

<u>10.1.3.4.1 Amount of Land Required</u> - Mechanical towers for plant A would be located northeast of plant A, whereas the towers for plant B would be located southwest of plant B. The towers for each

plant would be on a plâteau with a finished grade of 520 feet. The total amount of land occupied by both tower schemes would be approximately 96 acres. Since the land occupied by these towers would be within the proposed site boundary, no additional land offsite would need to be procured.

The spray canal would be located within a section extending from northeast of plant A to southwest of plant B. The average width of the canal is about 300 feet and the length is approximately 19,000 feet. The elevation of the water surface in the canal is 482 feet. The approximate area of the canal is 250 acres. The canal will stay within the bounds of the proposed site boundary. Consequently, no land outside the proposed site would be required.

The lake with spray canal would occupy approximately 4,300 acres. This would result in the flooding of communities of Dixon Springs and Johntown. The lake would also inundate a portion of state route 25, farms, forest and open land, **archaeological and historical** sites. This would require the purchase of approximately 5,000 acres of property in addition to that within the proposed site boundary.

10.1.3.4.2 Impacts of Construction Activities -

10.1.3.4.2.1 Amenities - Construction of all alternative heat dissipation schemes except the cooling lake would be restricted to the proposed plant site where other construction will be taking place. Therefore, these alternatives would not affect any people who would not be affected by other construction activities. Construction of these alternatives would therefore result in similar impacts.

Construction of the cooling lake alternative would affect approximately an additional 5,000 acres of land and the people presently located there. This would affect approximately an additional 500 people.

10.1.3.4.2.2 Accessibility of Historical Sites - Historic sites in the area surrounding the proposed plant site include Dixona, a house which is in the National Register of Historic Places, and Dixon Springs, a community with recognized historic value. A more detailed discussion of the historical significance of these is given in Section 2.3.1.1. Dixona is a private residence and presently neither it nor Dixon Springs is heavily visited. Of the alternatives considered, only the cooling lake would directly affect these sites. Although they would not directly affect these sites, the natural draft cooling towers and plumes would be visible from Dixona and would cause some visual impacts. The mechanical draft towers themselves would probably not be visible from off this site if appropriate design and screening techniques are used as much as practicable, but the plumes would be visible and a significant potential for ground fog in the areas would exist. The spray canal would have the least visual impact upon these sites because of its low profile. The potential fogging from it could, however, have considerable visual impacts. The cooling lake would inundate both of these sites.

10.1.3.4.2.3 Accessibility of Archaeological Sites - The archaeological surveys of the Hartsville generating plant site conducted in August 1972 located numerous areas of prehistoric habitation that will be further investigated before construction activities are undertaken.

Information concerning the size and interpretive value of most of these sites is still being gathered and is not available at this time. Several of the previously recorded archaeological sites, however, may be of significant interpretive value and will be investigated thoroughly. A testing program is being conducted to define the questionable sites recorded in preliminary surveys.

On each of the following schemes the direct impact on the various archaeological sites has been outlined. Each scheme is discussed as to the known importance of each archaeological site within the impact area. Sites that fall around the perimeter of the site are judged on the amount of physical change that construction of the system would produce. In many cases, testing of the site will prove that surface archaeological material is all that is remaining due to years of plowing and erosion. A sample of the archaeological remains must be retrieved from this type of site but intense excavations will not be necessary. Other sites with extended areas of undisturbed occupational zones (midden) will require more time and manpower to excavate. These sites may also prove to be stratified with a number of layers of habitation zones that must be excavated.

All significant archaeological sites will be investigated before any physical disturbance of the area is caused by TVA.

Mechanical Draft Towers (Wet and Wet/Dry - Schemes 1 and 4) - This scheme appears to have less impact on known archaeological sites than the others. It is confined to a smaller area and directly affects only six known archaeological areas. Sites 40-SM-51, 40-SM-52, and 40-SM-53 are closely concentrated and can be removed with a minimum

of difficulty. Surface indications (SI) 5 and 9 lie in the mechanical draft cooling towers area and should be tested for a better definition of these areas and their importance to the archaeology of the region. Site 40-TS-3 is located adjacent to the impacted area and might be affected by construction activities. If this site is affected, investigation would be necessary in this area. This site appears, from preliminary investigation, to be a very Early Archaic site with a dating range from 7000 BC to 5000 BC, based on the evaluation of the artifacts recovered from the site. There is also the possibility that an undisturbed habitational stratum exists below the plow zone which would not only increase the importance of this site locally, but for the middle Tennessee area as well. Investigators have recommended a careful testing program for this site to determine if the undisturbed zone exists. If this zone were found to exist, extensive excavation of the site would be planned as appropriate; if not, the site would be quickly released for construction.

Sites 40-SM-51, 40-SM-52, and 40-SM-53 appear to be of less interpretive value. They would, however, be tested for definition together with Surface Indications 5 and 9. This could be accomplished in a relatively short testing program. The locations of the affected areas are shown in Figure G-1.

<u>Spray canal scheme</u> - This scheme would directly affect two of the most extensive and important archaeological sites known in the plant site area. Sites 40-TS-3 and 40-SM-55 will require extensive testing and/or excavation before any construction activities commence. Site 40-SM-50 appears to have two components, Late Archaic

(2000 to 1000 BC) and Middle Woodland (1 AD to 500 AD). This site will require testing and may require limited excavation. In the preliminary survey an intense amount of lithic debris was noted, suggesting an intense occupation by prehistoric peoples.

The other sites in the impacted area will also require some degree of testing for definition of site area and cultural affiliation and to receive recommendations from field personnel about sites that may require further investigation. The location of the affected sites are shown in Figure G-1.

Cooling lake scheme - A major archaeological surveying and excavation effort would be required for this scheme. The projected reservoir would inundate or destroy almost all known archaeological resources in the area and would require TVA to survey all areas of impoundment along with excavation of many archaeological sites of significant interpretive value. Besides the unknown factors involved in this reservoir area, the system's northwest dam across Dixon Creek extends beside site 40-SM-55, which is an important Archaic site with a deep midden deposit, and also runs through site 40-SM-43, an extensive Mississippian (cultural) site with a large mound located within the site area. These are two of the most important known archaeological sites in the area, and other sites of significant importance may be located within the impacted area.

This scheme is highly undesirable from an archaeological standpoint because of the difficulty required to accomplish an adequate survey and excavation program. The affected sites are shown in Figure G-1.

10.1.3.4.2.4 Construction Impacts on Wildlife - Construction impacts on wildlife result primarily from the destruction

of habitat. It is expected that tower construction activity would take place primarily in the immediate area around the plant. This area would be expected to be disturbed in any case so that it is not expected that these alternatives would cause additional impacts on wildlife in two areas. Construction of the spray canal would affect wildlife in two areas. First, construction would require significant relocation of Dixon Creek, thereby disrupting terrestrial and aquatic habitat. Secondly, considerable area on portions of the site would be affected which would not be disturbed otherwise. Construction of the cooling lake would require the destruction of approximately 4,300 acres of existing habitat.

10.1.3.4.2.5 Land Erosion - Assuming erosion control measures equal for all alternatives, erosion effects would be proportional to the amount of land disturbed. Detailed estimates on the amounts of erosion for the alternatives are not available as complete information on the availability of suitable fill soil has not yet been completed. It is estimated that relative erosion rates will be proportional to the amount of land affected. Amounts of land and estimates for cut and fill are shown below.

Scheme	Type	Land Area Affected (Acres)*	Excavation Cut (yd^3)	Excavation Fill (yd^3)
1	Mechanical Draft Towers	96	650,000	3,471,000
2	Spray Canal	250	2,826,000	2,122,000
3	Lake w/Spray Canal	4,300	1,514,000	7,414,000
4	Wet/Dry Towers	96	650,000	3,471,000

*Excludes borrow areas which will be needed to obtain necessary fill material.

10.1.3.4.3 Impact of Plant Operation -

10.1.3.4.3.1 Impacts on People - The primary effect on people surrounding the plant will be the noise associated with machinery of the plant.

Using preliminary design information and estimating those factors which are not yet quantifiable, the noise levels of the cooling system are approximated as follows.

Cooling Pond with Spray Canal - A sound pressure level of 45 decibels is estimated at 1,000 feet from the source.[a] This distance approximates the nearest plant boundary.

Spray Canal - A sound pressure level of 59 decibels is estimated at 400 feet from the source.[b] This distance approximates the nearest plant boundary.

Mechanical Draft Cooling Towers - Sound pressure levels depend strongly on the orientation and arrangement of the towers and on the location of the listening station with respect to the facility geometry. Using the conceptual arrangement of eight towers arranged in two groups of four towers, each in opposite corners of the plant, the following estimates are derived.

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a. This estimate was computed by arbitrarily placing the 250 spray modules in 25 groups of 10 each, equally spaced along the canal. Each group was considered an independent point source of noise in estimating the total facility noise.

b. This estimate was calculated by arbitrarily placing the 700 spray modules in 10 groups of 70 each, equally spaced along the canal. Each group was treated as an independent point source of noise in estimating the total facility noise.

At the roadway east of the tower site (distance of approximately 300 feet) the noise level will be about 91 decibels.[c]

At a distance of 1,000 feet broadside of two towers a sound pressure level of 69 decibels is expected.[d]

A sound pressure level of 47 decibels is estimated at a distance of 1 mile from either group of four units.

Summary - Heat Dissipation Alternatives - The following table provides a comparison of estimated noise levels from the various alternatives under equivalent conditions.

ESTIMATED NOISE LEVELS ONE MILE FROM SOURCE

System	Estimated Sound Pressure Level, Decibels
Cooling Pond with Spray Canal	30
Spray Canal	37
Mechanical Draft Cooling Towers	47

The influence of meteorological conditions, foliage, architectural or plant structures, topography, and other surface conditions are not considered in these estimates. Actual noise levels may depend significantly on these factors.

10.1.3.4.3.2 Aesthetic Impacts - From an aesthetic standpoint the mechanical draft towers are considered displeasing. The materials of the mechanical draft tower are not compatible with the architecture of the total facility. The extensive site work required

c. Noise from the nearest tower predominates to the extent that contribution by adjacent towers is not significant.

d. Computations are based on the assumption that two adjacent cooling towers would constitute a line source of noise 1,500 feet long with 28 equally spaced 200-horsepower motors.

to accommodate the towers would likely alter the character of the total site. Finally, one bank of the mechanical towers would be located in view of State Highway 25 and the access road to the site which would tend to give the facility a cluttered look.

The spray canal is judged to be aesthetically unpleasant. Heat dissipation through the use of spray canals in most cases offers a design solution with a very low visual impact. The Hartsville site is an exception to the above premise because the existing topography does not lend itself to the construction of the canal. The land area required to cut the needed canal and its close proximity to Highway 25 and the proposed plant entrance road gives this alternative a very high visual impact. A large flat linear canal forced into the rolling country side would not be the most sensitive design approach for the Hartsville site. The site work required for the canal plus site work required for the plant proper would leave virtually none of the existing site to the south and east of the plant intact. The visual impact of such extensive site work would not be in keeping with a good environmental design approach.

Aesthetically the cooling pond with spray canal is generally pleasant. The pond would work aesthetically both with the plants and surrounding landscape. The pond would supply a major natural focal point which would complement the facility and reduce its visual impact. However, the pond would inundate structures which are presently aesthetically pleasing, i.e., architectural structures such as ante-bellum homes which represent a typical social and architectural period of middle Tennessee.

10.1.3.4.3.3 Impact on Wildlife - The major impacts on wildlife from operation of the alternatives would be from land use changes. The tower alternatives are expected to be located in the general area of the plant and would have minimum additional impacts. The cooling lake and spray canal schemes would have large impacts on terrestrial wildlife due to the loss of habitat, but could provide additional aquatic habitat and shore-type habitat. The net impacts on wildlife cannot be quantified at this time.

10.1.3.4.3.4 Flood Control - None of the alternatives would have any significant effects on flood control.

10.1.3.4.4 Impacts Due to Salts Discharged in Drift - As discussed in Section 5.1.7, essentially all of the solids discharged from the heat dissipation alternatives as drift would reach the ground within 2,000 feet of their emission point. Therefore, this salt deposition would occur inside the plant boundary. In any case, the solids contained in the drift would primarily consist of those present in the reservoir. Drift rates and constituent salts concentrations for the alternative systems are listed below.

HEAT DISSIPATION ALTERNATIVE DRIFT RATES

AND SALTS CONCENTRATIONS

Alternative	Drift Rate	Salts Concentration*	Mass of Salts in Drift
	GPM	mg/l	lbs/day
Natural Draft Towers	180	160	484
Mechanical Draft Towers	250	160	672
Spray Canal	130	160	350

HEAT DISSIPATION ALTERNATIVE DRIFT RATES

AND SALTS CONCENTRATIONS (Continued)

Alternative	Drift Rate	Salts Concentration*	Mass of Salts in Drift
	GPM	mg/l	lbs/day
Lake with Spray Canal	50	160	134
Wet/Dry Towers	240	160	645

*Assuming normal operation; based on a concentration factor (CF) = 2.

10.1.3.4.5 Transmission Route Selection - It is not expected that any of the alternatives would affect the selection of the route for the transmission lines. Therefore, there would be no significant difference in the environmental impact for the transmission lines for any alternative heat dissipation systems.

10.2
10.3

References for 10.1

1. Research on Dry-Type Cooling Towers for Thermal Electric Generation, Part I: J. P. Rossie and E. A. Cecil, R. W. Beck and Associates, Environmental Protection Agency, Project #16130EES, November 1970.

2. Cost Comparison of Dry-Type and Conventional Cooling Systems for Representative Nuclear Generating Plants: J. P. Rossie, et al, USAEC Report TID-26007.

3. Boatman, Howard, January 28, 1974: Letter to M. I. Foster, Director of the Division of Navigation Development and Regional Studies, Tennessee Valley Authority, Knoxville, Tennessee. Mr. Boatman is the Chief, Operations Division, Department of the Army, Nashville District Corps of Engineers, Nashville, Tennessee.

4. U.S. Department of Commerce, NOAA, EDS, 1973: "Local Climatological Data, Annual Summary with Comparative Data, Nashville, Tennessee, 1972." U.S. Department of Commerce, National Climatic Center, Asheville, North Carolina.

TABLE 10.1-1

ALTERNATIVE HEAT DISSIPATION SYSTEMS DESCRIPTIVE DATA

Scheme No.	Proposed	1	2	3	4
Type of Cooling Equipment	Natural Draft Towers	Mechanical Draft Towers	Spray Canal	Lake with Spray Canal	Wet/Dry Towers
Figure No.		10.1-1	10.1-2	10.1-3	10.1-1
No. of Towers Per Unit	1	2	-	-	2
Circulting Water Flow, GPM/Unit	450,000	620,000	560,000	580,000	590,000
Cooling Range, °F.	36.0	26.2	29.0	28.0	27.5
Design Approach at 55 F Wet Bulb	20	28	28	27	30

TABLE 10.1-2

ALTERNATIVE HEAT DISSIPATION SYSTEMS PERFORMANCE DATA

(Totals for Four Units)

Scheme No.	Proposed	1	2	3	4
Type of Cooling Equipment	Natural Draft Towers	Mechanical Draft Towers	Spray Canal	Lake with Spray Canal	Wet/Dry Towers
Annual Average Net Turbine Heat Rate, Btu/kWh	9,854	9,859	9,885	9,864	9,877
Annual Average Net Plant Output, kW	4,827,300	4,803,500	4,776,500	4,834,100	4,791,800

Note: The net turbine heat rates and net plant outputs listed in this table are based on a typical nuclear turbogenerator unit which has a net turbine heat rate of 9,774 Btu/kWh at 2.0 inches HgA back pressure. These values are subject to change when the turbogenerator contract is awarded, but the differences between alternatives will be only slightly affected.

TABLE 10.1-3

ALTERNATIVE HEAT DISSIPATION SYSTEMS EVAPORATION, DRIFT, AND BLOWDOWN

(Four Unit Totals)

Scheme No.	Proposed	1	2	3	4
Type of Cooling Equipment	Natural Draft Towers	Mechanical Draft Towers	Spray Canal	Lake with Spray Canal	Wet/Dry Towers
Evaporation, GPM					
Annual Average	50,000	50,000	52,000	58,000	42,000
Maximum	58,000	58,000	60,000	104,000	52,000
Drift, GPM	180	250	130	50	240
Annual Average Blowdown, GPM	50,000	50,000	52,000	58,000	42,000

TABLE 10.1-4

ALTERNATIVE HEAT DISSIPATION SYSTEMS COST DATA

(Four Unit Totals, Escalated to Commercial Operation Date)

Scheme No.		1	2	3	4
Type of Cooling Equipment	Natural Draft Towers	Mechanical Draft Towers	Spray Canal	Lake With Spray Canal	Wet/Dry Towers
Facilities Cost	160,000,000	138,000,000	178,000,000	179,000,000	160,000,000
Operation Cost	24,960,000	35,430,000	43,590,000	20,090,000	37,790,000
Relative Operating Cost	0 (Base)	10,470,000	18,630,000	(4,870,000)	12,830,000
Capacity Replacement Cost	12,050,000	12,980,000	17,370,000	13,960,000	15,733,000
Relative Cap., Repl. Cost	0 (Base)	930,000	5,320,000	1,910,000	3,683,000
Maintenance Cost	1,900,000	2,260,000	4,970,000	2,190,000	2,810,000
Total Evaluated Present Worth Cost	$198,910,000	$188,670,000	$243,930,000	$215,240,000	$216,330,000
Total Relative Cost		(10,240,000)	45,020,000	16,330,000	17,420,000
Salvage Value of Land Purchased for Lake				3,450,000	
Net Total Cost of Lake				$211,790,000	
Net Relative Cost of Lake				12,880,000	

Table 10.1-5

ESTIMATED COSTS OF HEAT REJECTION ALTERNATIVES

Alternate System	Total Cost*
Natural Draft Wet Cooling Tower	198,910,000
Wet/Dry Mechanical Draft Cooling Tower	216,330,000
Mechanical Draft Cooling Tower	188,670,000
Spray Canal	243,930,000
Cooling Lake	211,790,000 (Includes reduction for salvage value of pond)

*Costs are in terms of 1981 dollars. The estimate reflects facilities costs, present-worth operating and maintenance costs.

Table 10.1-6

VOLUME OF WATER REQUIRED TO DILUTE CHEMICAL DISCHARGES FROM HEAT DISSIPATION ALTERNATIVE SYSTEMS TO MEET APPLICABLE WATER QUALITY STANDARDS

Condenser Cooling Water System Only

				Heat Dissipation Alternatives-Volume of Dilution Water Required to Meet Effluent Guideline or Maximum Stream Limit														
				Spray Canal CF=2[4]			Cooling Lake with Spray Canal CF=2.5[4]			Mechanical Draft Cooling Towers CF=4.0[4]			Natural Draft Cooling Towers CF=4.4[4]			Natural Draft Cooling Towers CF=6.6[5]		
Parameter	Cumberland River Water Quality[1]	Effluent Guideline[2]	Maximum Stream Limit[3]	Effluent Conc.	Conc. in River After Mixing	Dilution Water Required	Effluent Conc.	Conc. in River After Mixing	Dilution Water Required	Effluent Conc.	Conc. in River After Mixing	Dilution Water Required	Effluent Conc.	Conc. in River After Mixing	Dilution Water Required	Effluent Conc.	Conc. in River After Mixing	Dilution Water Required
	mg/l	mg/l	mg/l	mg/l	mg/l	gal.	mg/l	mg/l	gal.	mg/l	mg/l	gal.	mg/l	mg/l	gal.	mg/l	mg/l	gal.
Dissolved Solids	80	-	500	160	88	0	200	92	0	320	104	0	352	107	0	528	125	0
Suspended Solids	32	40	-	64	36	0	80	37	0	128	42	0	141	43	0	211	50	0
Ammonia	0.002	5.0	(0.5)	0.004	0.002	0	0.005	0.002	0	0.008	0.003	0	0.009	0.003	0	0.013	0.003	0
Fluoride	0.06	20.0	(1.0)	0.12	0.06	0	0.15	0.07	0	0.24	0.08	0	0.26	0.08	0	0.40	0.09	0
Chloride	3	-	(250)	6	3.3	0	7.5	3.5	0	12	3.9	0	13.2	4	0	20	4.7	0
Sulfate	25	1,400	(250)	50	28	0	62.5	29	0	100	33	0	110	34	0	165	39	0
Total Phosphate[6]	0.08	1.0	(0.08)	0.16	-	-	0.20	-	-	0.32	-	-	0.35	-	-	0.53	-	-
Silica	4.7	-	50[7]	9.4	5.2	0	11.8	5.4	0	18.8	6.1	0	20.7	6.3	0	31.0	7.3	0
Total Iron[6]	1.0	10.0	(0.3)	2.0	-	-	2.5	-	-	4.0	-	-	4.4	-	-	6.6	-	-
Manganese[6]	0.12	10.0	(0.05)	0.24	-	-	0.30	-	-	0.48	-	-	0.53	-	-	0.79	-	-
Copper	*	1.0	(0.02)	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	0.02	2.0	(0.1)	0.04	0.02	0	0.05	0.02	0	0.08	0.03	0	0.09	0.03	0	0.13	0.03	0
Chromium[6]	*	3.0	(0.05)	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-
Aluminum[6]	1.6	250	(1.0)	3.2	-	-	4.0	-	-	6.4	-	-	7.0	-	-	10.6	-	-
Nickel	*	3.0	(0.1)	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-
Silver	*	0.05	(0.005)	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-
Sodium[6]	3.4	-	(100)	6.8	3.8	0	8.5	3.9	0	13.6	4.4	0	15.0	4.6	0	22.4	5.3	0
Potassium[6]	1.9	6.0	(1.9)	3.8	-	-	4.8	-	-	7.6	-	-	8.4	-	-	12.5	-	-
Lead	*	0.1	(0.05)	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-
Mercury	0.0006	0.005	(0.005)	0.0012	0.0007	0	0.0015	0.0007	0	0.0024	0.0008	0	0.003	0.0008	0	0.004	0.0009	0
Barium	*	5.0	(1.0)	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	*	1.0	(0.01)	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	*	0.01	(0.01)	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-
Selenium	*	0.01	(0.01)	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-
Boron	*	500	(1.0)	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-

1. Maximum concentrations of parameters in grab sample taken from Cordell Hull Dam tailrace (CRM 313.5) in May, July, and September 1973.
2. Established by Tennessee Water Quality Control Board, January 1973.
3. Sources of maximum stream limits are Tennessee water quality standards and (guidelines) and Water Quality Criteria.
4. CF (concentration factor): factor by which concentrations of parameters in raw river water are multiplied in heat dissipation system during 30-hour holdup of blowdown.
5. Maximum concentration factor expected during operation of plant.
6. Concentrations of these parameters in raw river water equal or exceed maximum stream limit.
7. Suggested maximum stream limit was obtained from McKee and Wolfe, Water Quality Criteria, 1968.

*Below detectable limits.

TABLE 10.1-7

COST/BENEFIT ANALYSIS OF HEAT DISSIPATION ALTERNATIVES

Alternatives:	Units	Towers Natural Draft Wet	Towers Mechanical Draft Wet	Cooling Lake	Spray Canal	Towers Mechanical Draft Wet/Dry
Cost: Present Worth:		198,910,000	188,670,000	215,240,000[a]	243,930,000	216,330,000
Annualized:		17,066,000	16,188,000	18,468,000	20,929,000	24,210,000
Incremental Cost:		Base	(10,240,000)	16,330,000	45,020,000	17,420,000
Environmental Costs						
Natural Surface Water Body						
1.1 Impingement or entrapment by cooling water intake structure						
1.1.1 Fish	Δ % of harvestable crop	Base	0	0	0	0
1.2 Passage through or retention in cooling systems	% of base					
1.2.1 Phytoplankton and zooplankton	Destroyed	Base	0	16	4	(16)
1.2.2 Fish	Entrained	Base	0	16	4	(16)

TABLE 10.1-7 (Continued)

Environmental Costs	Units	Towers Natural Draft Wet	Towers Mechanical Draft Wet	Cooling Lake	Spray Canal	Towers Mechanical Draft Wet/Dry
1. Natural Surface Water Body (Continued)						
1.3 Discharge area and thermal plume	Δ Acres	Base	0	0	0	0
1.4 Chemical effluents	% Discharged	Base	0	16	4	(16)
1.5 Radionuclides discharged to water body	Δ Nuclides Released	Base	0	0	0	0
1.6 Consumptive use						
1.6.1 People	Δ Gallons Available	Base	0	0	0	0
1.6.2 Agriculture	Δ Gallons Available	Base	0	0	0	0
1.6.3 Industry	Δ Gallons Available	Base	0	0	0	0
1.7 Plant construction (including site preparation)	Acre-Fect of Runoff	Base	2.6	14.5	325.2	2.6
1.8 Other impacts	Qualified Opinion	Base	See text	See text	See text	See text
1.9 Combined or interactive effects		None Identified				
1.10 Net effects	Opinion	See text	See text	See text	See text	See text

TABLE 10.1-7 (Continued)

Environmental Costs	Units	Towers Natural Draft Wet	Towers Mechanical Draft Wet	Cooling Lake	Spray Canal	Towers Mechanical Draft Wet/Dry
2. Ground Water						
2.1 Raising/lowering of ground water levels		Base	0	0	See text	See text
2.2 Chemical contamination of ground water (including salt)						
2.2.1 People		See text	See text	See text	See text	See text
2.2.2 Plants		See text	See text	See text	See text	See text
3. Air						
3.1 Fogging and icing (caused by evaporation and drift)	Δ Hour/year	Base	1,695	5,614	1,729	1,684
3.1.1 Ground transportation	Δ Vehicles/year	Base	287,350	484,000	231,050	260,650
3.1.2 Air transportation	Δ Hour/year	Base	0	0	0	0
3.1.3 Water transportation	Δ Hour/year	Base	460	560	645	435
3.1.4 Plants	Qualified Opinion	Base	See Text	See Text	See Text	See Text
3.2 Chemical discharge to ambient air	Qualified Opinion	Base	No effects	No effects	No effects	No effects

TABLE 10.1-7 (Continued)

Environmental Costs	Units	Towers Natural Draft Wet	Towers Mechanical Draft Wet	Cooling Lake	Spray Canal	Towers Mechanical Draft Wet/Dry
3.3 Radionuclides discharged to ambient air and direct radiation from radioactive materials		No effects	No effects	No effects	No effects	No effects
3.4 Other impacts on air		None identified				
4 Land						
4.1 Site selection						
4.1.1 Land, amount	Acres	Base	34	4,238	188	34
4.2 Construction activities (including site preparation)						
4.2.1 People (amenities)	No affected	Base	0	500	0	0
4.2.2 People (accessibility of historical sites)	No affected	See text	See text	See text	See text	See text
4.2.3 People (accessibility of archaeological sites)	Sites affected	See text	See text	See text	See text	See text
4.2.4 Wildlife	Acres of habitat	Base	0	4,300	See text	0
4.2.5 Land (erosion)	See text	See text	See text	See text	See text	See text

TABLE 10.1-7 (Continued)

	Environmental Costs	Units	Towers Natural Draft Wet	Towers Mechanical Draft Wet	Cooling Lake	Spray Canal	Towers Mechanical Draft Wet/Dry
4.3	Plant operation						
	4.3.1 People (amenities) (noise)	Decibels	Base	+9	(8)	(1)	+9
	4.3.2 People (aesthetics)	Qualified Opinion	Base	Unpleasant	See text	See text	Unpleasant
	4.3.3 Wildlife	Qualified Opinion	See text	See text	See text	See text	See text
	4.3.4 Land, flood control	Acres	Base	0	0	0	0
4.4	Salts discharged from cooling towers	Grams/day	Base	7,200	(7,900)	(3,000)	3,600
4.5	Transmission route selection						
	4.5.1 Land, amount	Acres	Base	0	0	0	0
	4.5.2 Land use and land value	Dollars	Base	0	0	0	0
	4.5.3 People (aesthetics)	Opinion	Base	0	0	0	0
4.6	Transmission facilities construction						
	4.6.1 Land adjacent to right of way	Miles	Base	0	0	0	0
	4.6.2 Land, erosion	Tons	Base	0	0	0	0
	4.6.3 Wildlife	Number	Base	0	0	0	0
	4.6.4 Flora	Opinion	Base	0	0	0	0

TABLE 10.1-7 (Continued)

Environmental Costs	Units	Towers Natural Draft Wet	Towers Mechanical Draft Wet	Cooling Lake	Spray Canal	Towers Mechanical Draft Wet/Dry
4.7 Transmission line operation						
4.7.1 Land use	Dollars	Base	0	0	0	0
4.7.2 Wildlife	Opinion	Base	0	0	0	0
4.8 Other land impacts	None identified					
4.9 Combined or interactive effects	None identified					
4.10 Net effects	Opinion	See text	See text	See text	See text	See text

a. Does not include salvage value.

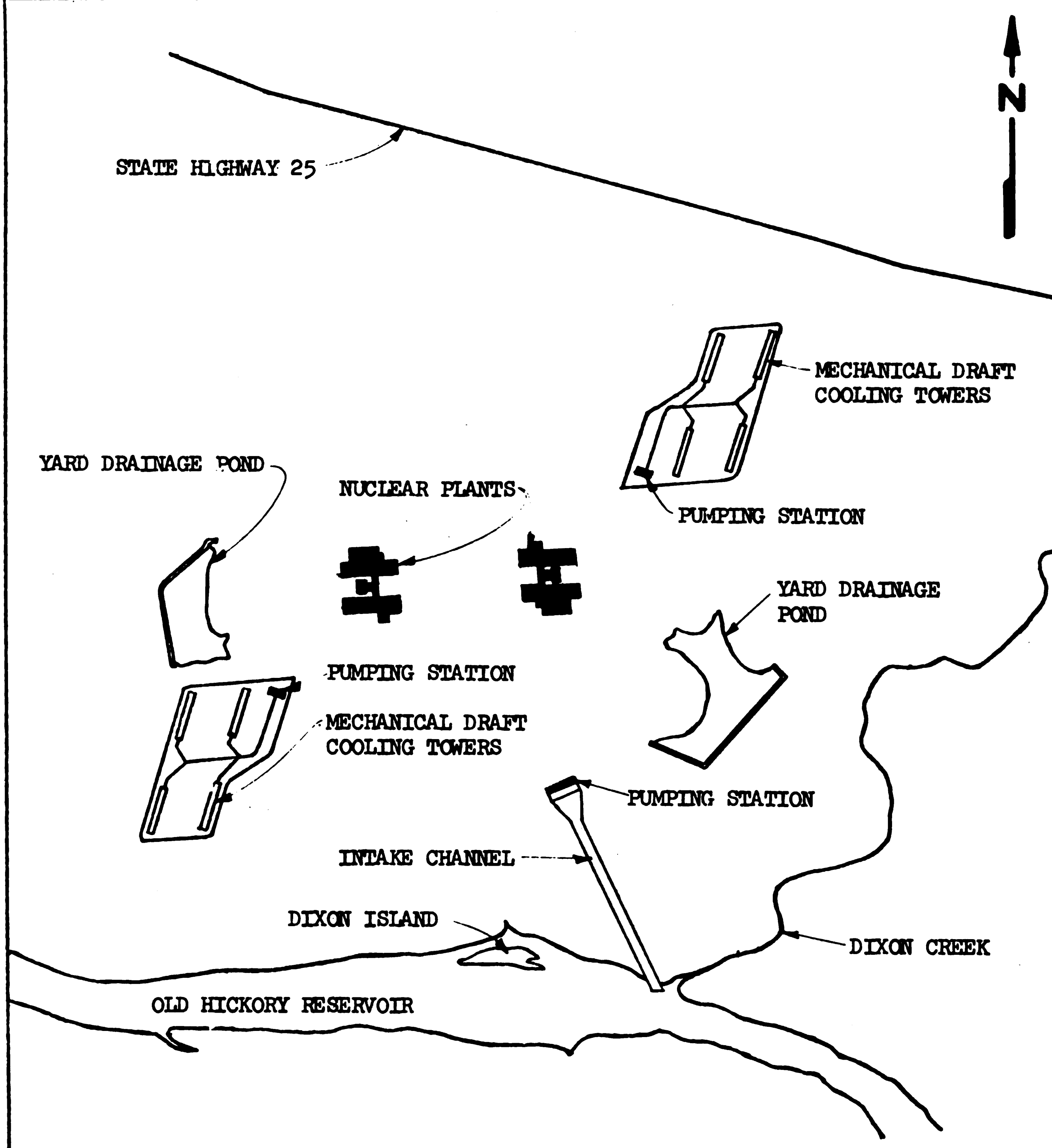


Figure 10.1-1

COOLING WATER ALTERNATIVE
HARTSVILLE NUCLEAR PLANT
MECHANICAL DRAFT COOLING TOWER

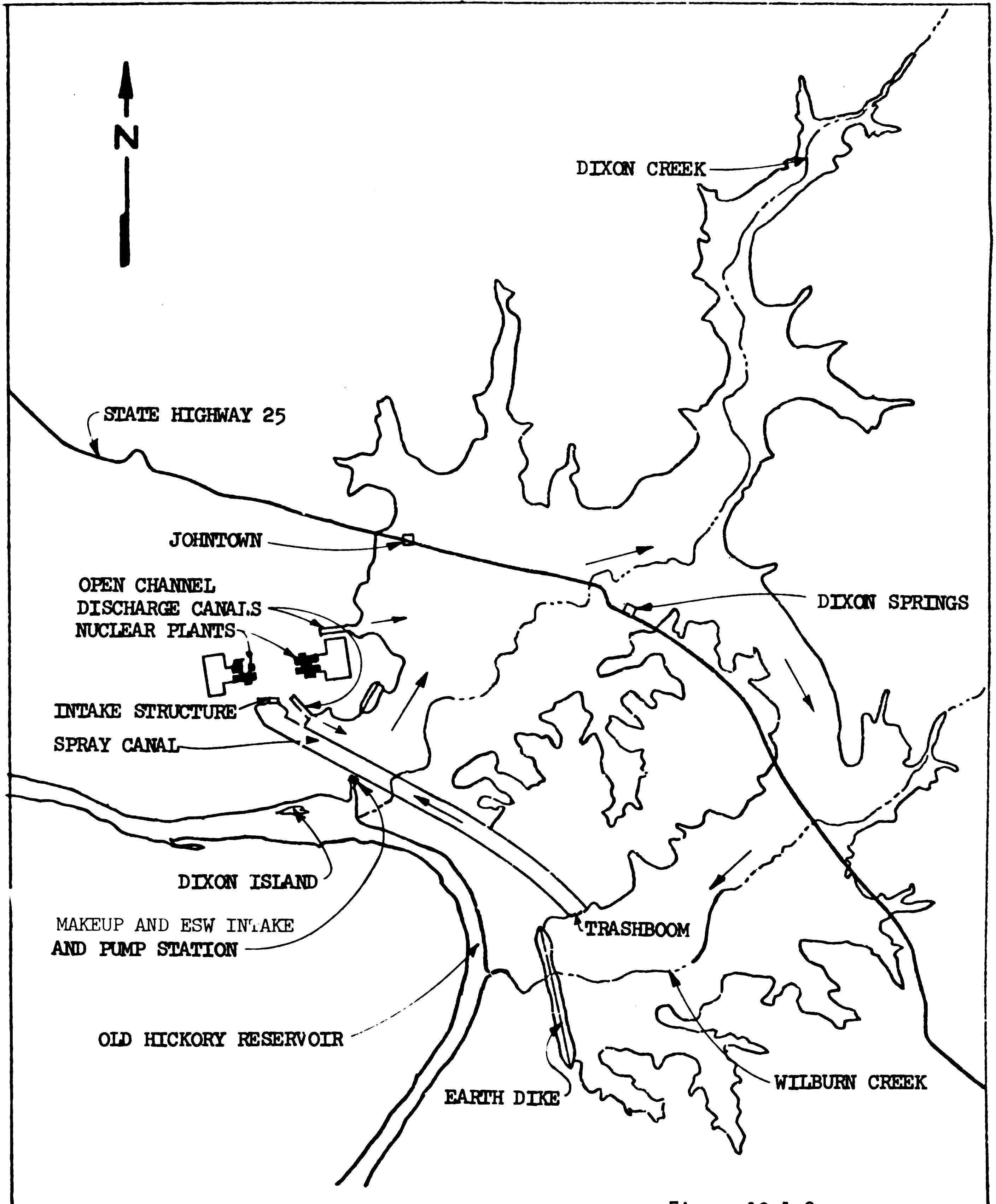


Figure 10.1-2

COOLING WATER ALTERNATIVE
HARTSVILLE NUCLEAR PLANT
SPRAY CANAL WITH COOLING LAKE

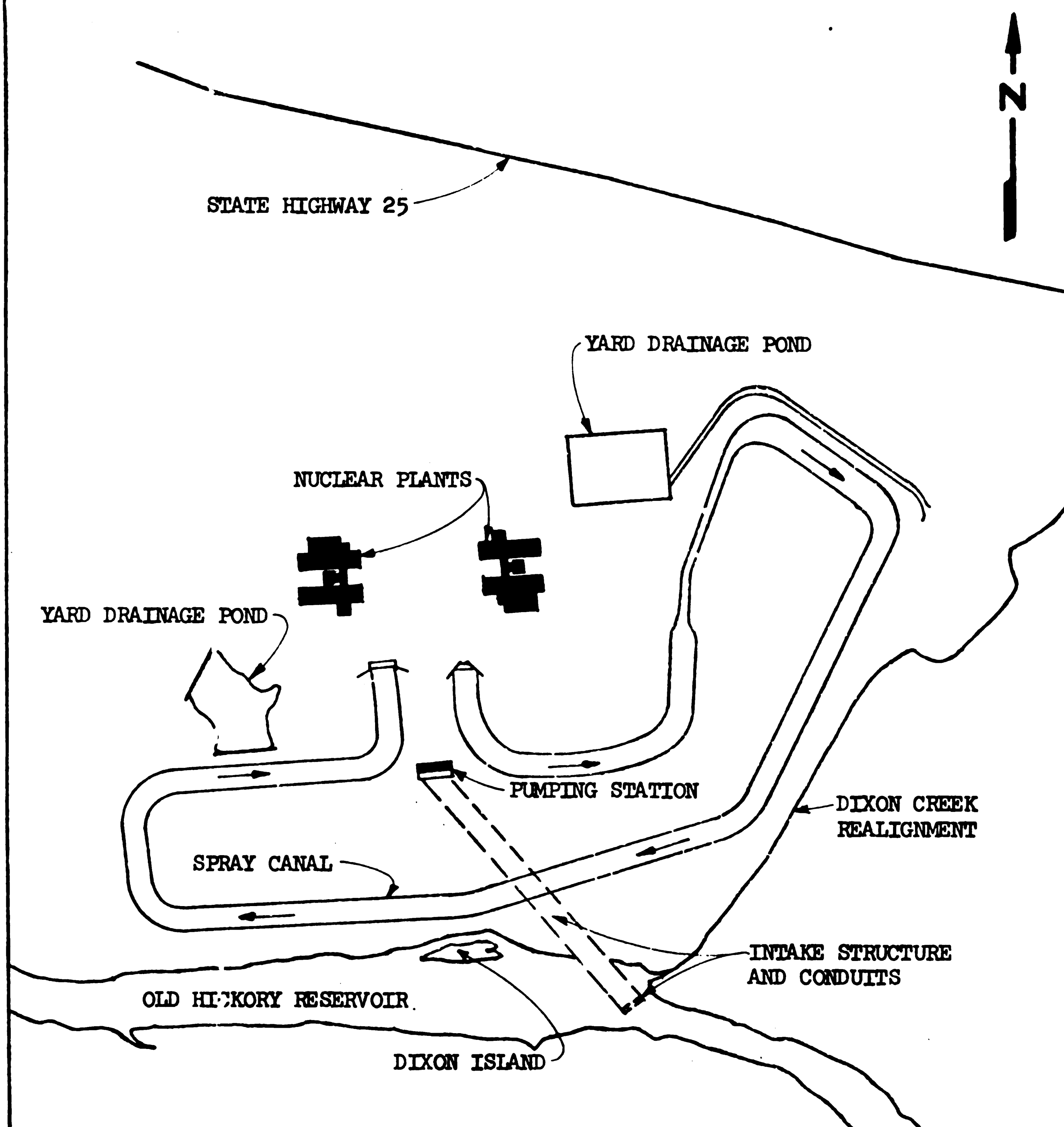


Figure 10.1-3

COOLING WATER ALTERNATIVE
HARTSVILLE NUCLEAR PLANT
SPRAY CANAL

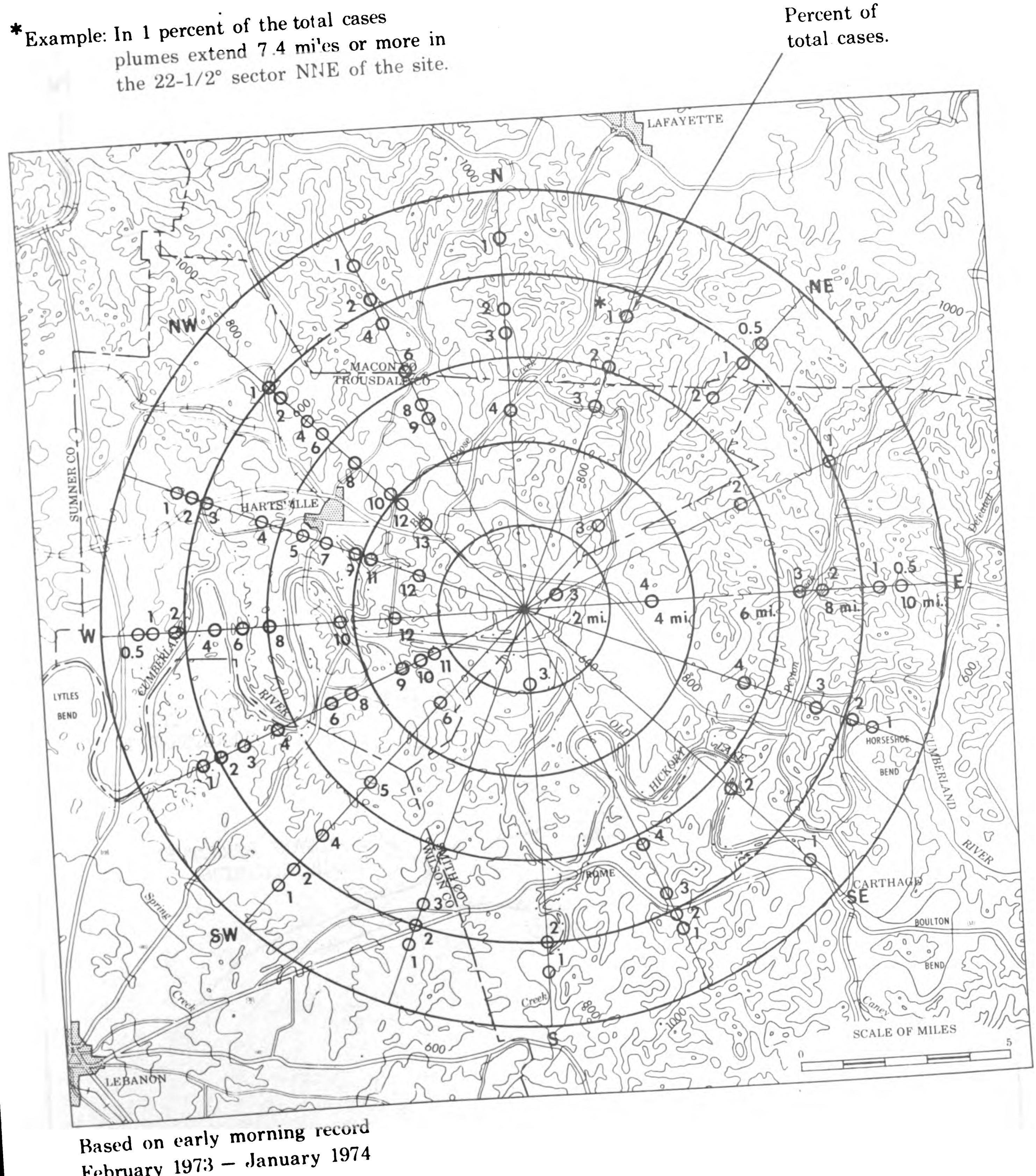
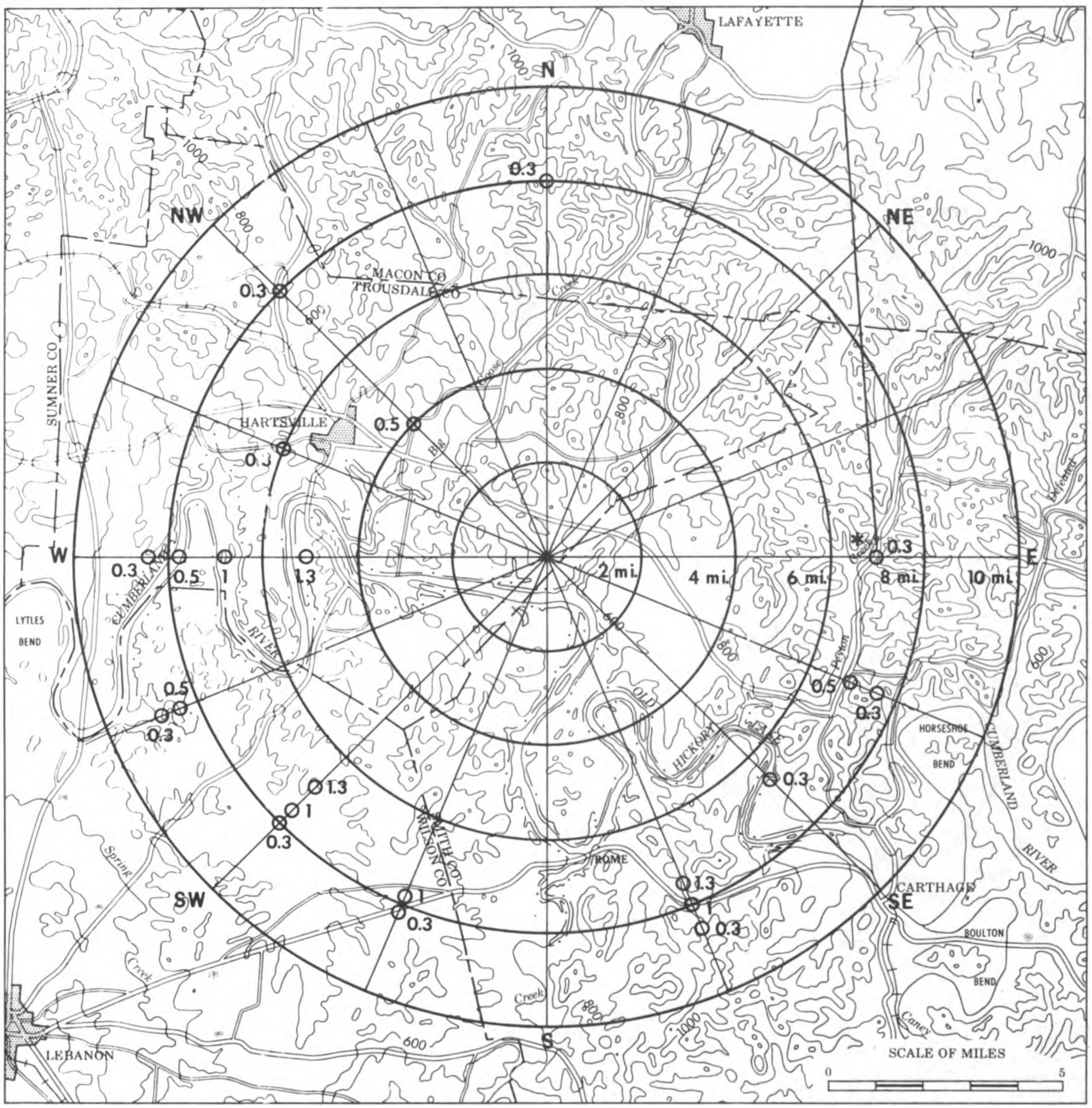


Figure 10.1-4 EXPECTED PLUME LENGTH AND FREQUENCY OF OCCURRENCE FOR 16 COMPASS POINT SECTORS MECHANICAL DRAFT (WET) COOLING TOWERS (ALL TEMPERATURES) HARTSVILLE NUCLEAR PLANTS

*Example: In 0.3 percent of the total cases plumes extend 7 miles or more in the 22-1/2° sector E of the site.

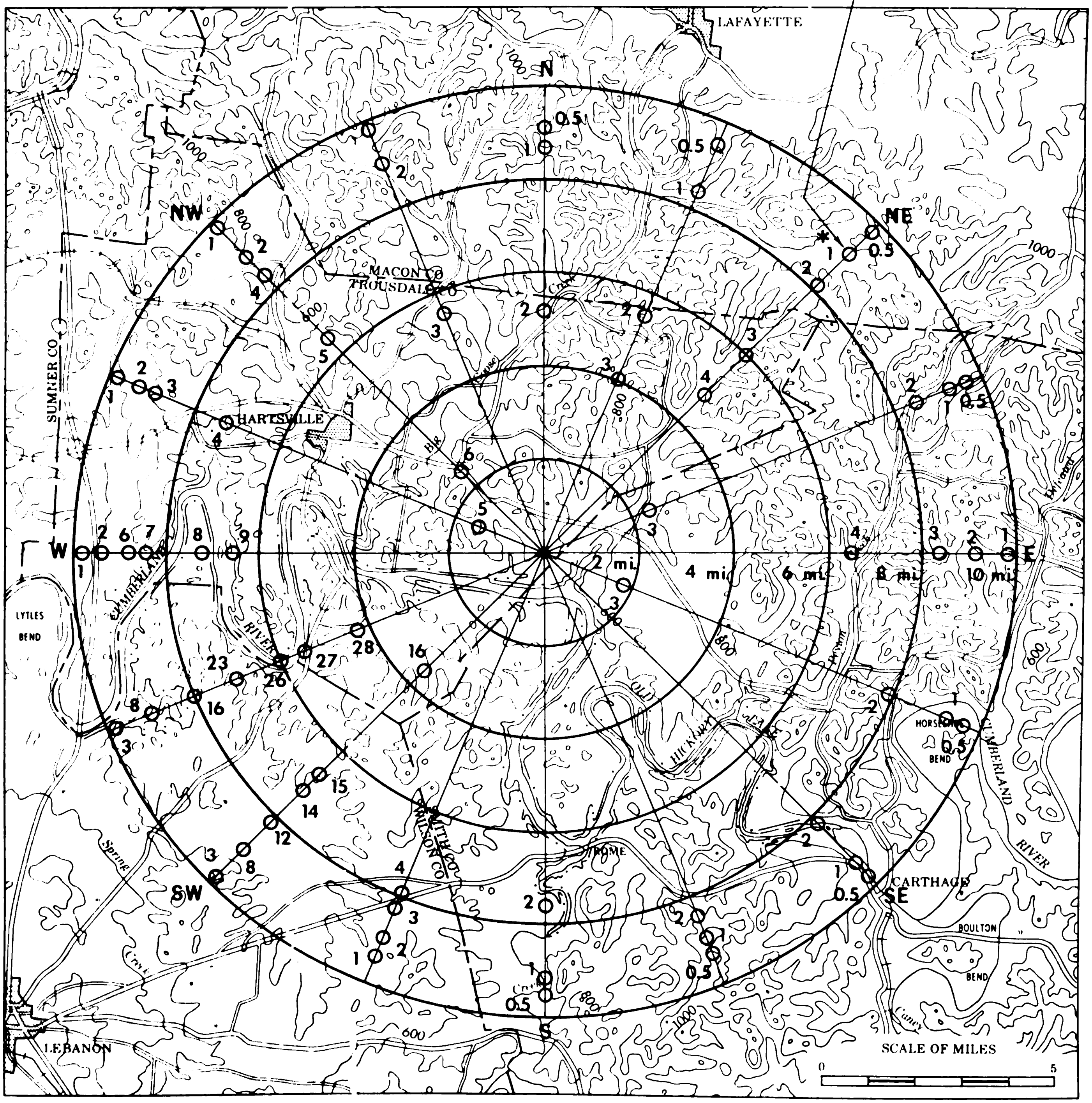


Based on early morning record
February 1973 - January 1974

Figure 10.1-5 EXPECTED PLUME LENGTH AND FREQUENCY OF OCCURRENCE FOR 16 COMPASS POINT SECTORS MECHANICAL DRAFT (WET) COOLING TOWERS (TEMPERATURES ≤ 32°F) HARTSVILLE NUCLEAR PLANTS

*Example: In 1 percent of the total cases plumes extend 9.2 miles or more in the 22-1/2° sector NE of the site.

Percent of total cases



Based on early morning record February 1973 – January 1974

Figure 10.1-6 EXPECTED PLUME LENGTH AND FREQUENCY OF OCCURRENCE FOR 16 COMPASS POINT SECTORS
SPRAY CANAL
(ALL TEMPERATURES)
HARTSVILLE NUCLEAR PLANTS

*Example: In 0.3 percent of the total cases plumes extend 8.7 miles or more in the 22-1/2° sector ENE of the site.

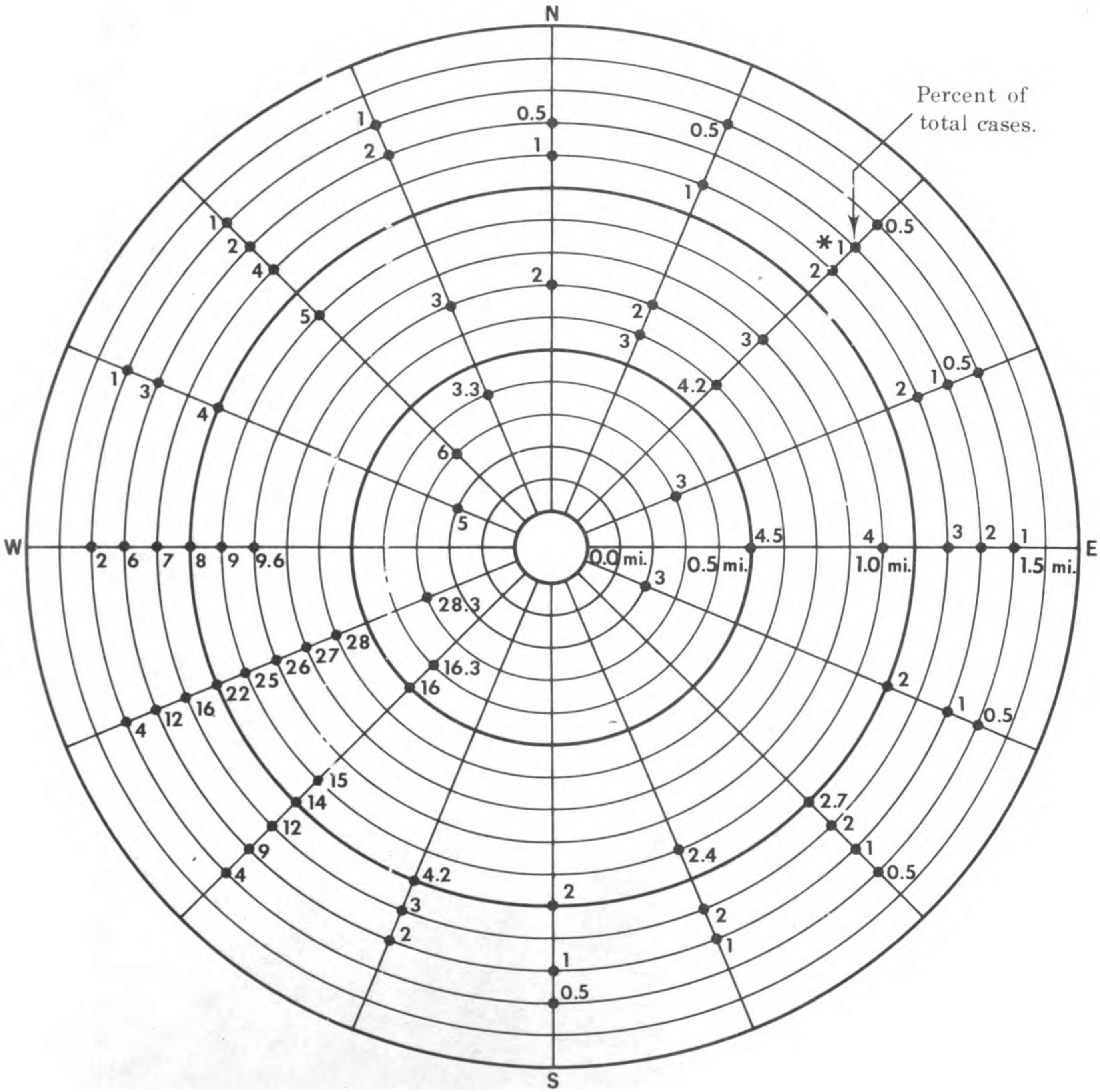
Percent of total cases

Based on early morning record
February 1973 - January 1974

Figure 10.1-7 EXPECTED PLUME LENGTH AND FREQUENCY OF OCCURRENCE
FOR 16 COMPASS POINT SECTORS
SPRAY CANAL
(TEMPERATURES ≤ 32°F)
HARTSVILLE NUCLEAR PLANTS

*Example: In 1 percent of the total cases plumes extend 1.2 miles or more in the 22-1/2° sector NE of the source point.

Note: The source point is assumed to be mid-way along the spray canal about 1 mile SE of the reactor site.

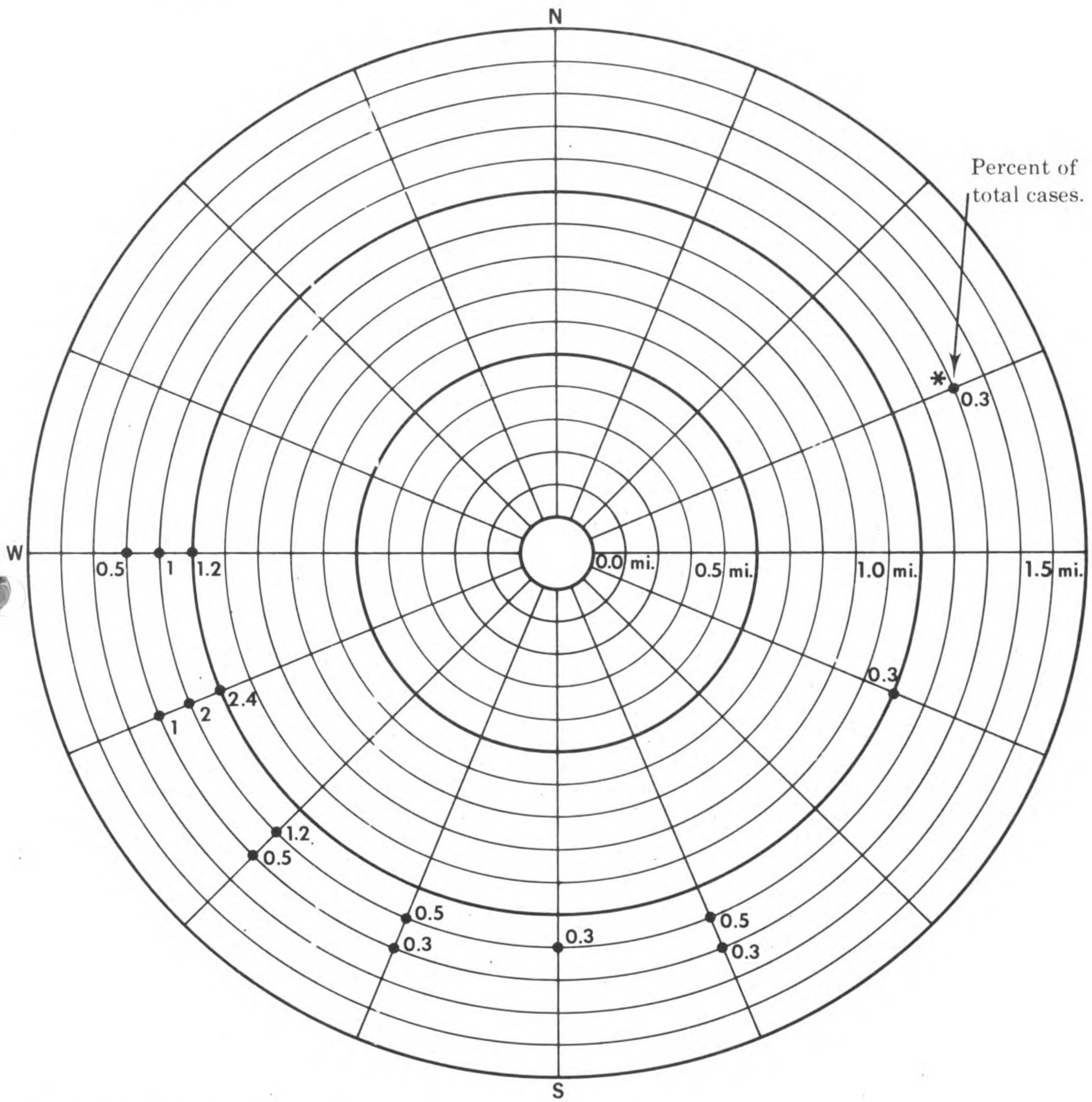


Based on early morning record
February 1973 - January 1974

Figure 10.1-8 EXPECTED PLUME LENGTH AND FREQUENCY OF OCCURRENCE FOR 16 COMPASS POINT SECTORS
SPRAY CANAL ASSOCIATED WITH COOLING LAKE
(ALL TEMPERATURES)
HARTSVILLE NUCLEAR PLANTS

*Example: In 0.3 percent of the total cases plumes extend 1.2 miles or more in the 22-1/2° sector ENE of the source point.

Note: The source point is assumed to be mid-way along the spray canal about 1 mile SE of the reactor site.



Based on early morning record
February 1973 - January 1974

Figure 10.1-9 EXPECTED PLUME LENGTH AND FREQUENCY OF OCCURRENCE FOR 16 COMPASS POINT SECTORS
SPRAY CANAL ASSOCIATED WITH COOLING LAKE
(TEMPERATURES ≤ 32°F)
HARTSVILLE NUCLEAR PLANTS

10.2 Cooling Tower Blowdown Treatment System

10.2.1 Rationale for Selection - The proposed natural draft cooling towers will operate such that the concentration of dissolved and suspended solids within the system will be maintained at approximately twice that of the reservoir. A blowdown from the cold side of the towers of approximately 50,000 gallons per minute will be utilized to maintain concentrations at this level. In order to try to minimize the environmental effects of this blowdown as much as practical, various systems were evaluated for treating the blowdown to remove dissolved and suspended solids.

Three alternative methods were investigated for handling cooling tower blowdown. The methods investigated were:

1. Normal Blowdown without Treatment
2. Partial Treatment and Discharge of Blowdown
3. Total Recycle of Cooling Water

After a review of the benefit/cost analyses used to balance the economic costs against the reduction in environmental impacts, the direct discharge of blowdown through a diffuser without additional treatment is selected as the optimum practical method for this purpose. A detailed description of this process is given in section 3.6.1.

The partial treatment alternative reduces total solids discharge by approximately one-half: at a river flow rate of 17,000 ft^3/s (see Section 2.5), the resulting solids concentrations in the river would be less than 1 percent lower than that resulting from direct discharge. This reduction does not appear to justify the $8 million cost. Also, discharges from the partial treatment system may not meet the proposed EPA guidelines for effluents when they are finally adopted as they would be applied to this plant. The

total recycle alternatives considered would undoubtedly meet the guidelines when adopted, but costs are extremely high (approximately $44 million for the least expensive alternative). In addition, both total recycle alternatives considered are unproven processes for this type of application and must be considered to be of questionable reliability until such plants are constructed and enough data collected to establish reliability levels.

In summary, considering the commitment of funds necessary to treat blowdown and the questionable reliability of techniques available, it is felt that TVA should not commit to treat blowdown. Since cooling tower blowdown consists of essentially only those elements found naturally in the river, cleanup of these elements would not be warranted at the enormous expense required.

If after the guidelines have been finalized, treatment is indicated then this design does not preclude the addition of whatever facilities might eventually be required.

10.2.2 Alternative Designs - A discussion of each of the alternative designs is included below. Some comparisons of operating conditions and effluent characteristics are given in tables 10.2.1 and 10.2.2.

10.2.2.1 Partial Treatment and Discharge of Blowdown - System Description:

The purpose of partial treatment is to reduce the amount of total solids returned to the receiving stream without removing all solids, thereby reducing the concentration of solids in the mixing zone.

Partial treatment would consist of a clarification and softening process utilizing magnesium carbonate with recycle of sludge. A schematic diagram of the magnesium carbonate partial treatment process is given in figure 10.2-1. The process would be initiated by the addition of a coagulant, magnesium carbonate, to the blowdown stream.

Magnesium carbonate was selected as a coagulant because the sludge associated with this process can be recycled. Also, additional $MgCO_3$ is produced since magnesium and carbonate are removed from the cooling water supply. When magnesium carbonate is added to water containing magnesium and calcium hardness, magnesium hydroxide and calcium carbonate precipitate. The magnesium hydroxide is weighted by calcium carbonate, causing it to settle in a sedimentation basin. Carbonation of this sludge with carbon dioxide dissolves the magnesium as magnesium bicarbonate, leaving a calcium carbonate sludge which is dewatered by vacuum filtration. The filtrate containing magnesium is recycled to the mixing chamber for reuse. Lime is also recycled for reuse.

The supernatant from the process would be discharged to the Cumberland River via the deepwater multiport diffuser. Effluent concentrations are shown in table 10.2-3. The solids residue would be disposed of in an approved landfill. Assuming average river water concentration, the removal rate of solids would be on the order of 40 tons per day.

The relative advantages and disadvantages are as follows:

Advantages:

1. pH of reaction destroys most bacteria and inactivates viruses.
2. A reduction of dissolved and suspended solids.
3. Improvement of water quality as compared to untreated blowdown.
4. Magnesium carbonate is produced in excess by the process and revenue could be generated by sale or the byproduct could be used at other power generation facilities as a coagulant in water treatment.
5. Eliminates sludge dewatering and disposal problem.

Disadvantages:

1. pH of effluent is about 1.5 points higher than makeup water pH.
2. Costs are high for reduction achieved.
3. Energy is consumed.
4. Plant reliability is reduced.

10.2.2.2 Total Recycle of Blowdown - Two total recycle methods were investigated. They are: (1) brine concentration by evaporation and (2) sidestream treatment using filtration, softening, reverse osmosis, and evaporation. Each of these methods is described below.

10.2.2.2.1 Brine Concentration by Evaporation -

System Description:

A brine concentration system having potential application to treatment and recycle of cooling tower blowdown has been marketed. The systems now being offered are low capacity, i.e., on the order of several hundred thousand gallons processed per day. A larger, special order, system would be required for condenser circulating water blowdown application for these plants. As now envisioned, the system

would consist of a sufficient number of one million gallon-per-day process modules to accommodate the desired blowdown flow. Each module would consist of the necessary equipment to transfer and process the blowdown. A process flow diagram for a single one million gallon-per-day module is shown in figure 10.2.2. A brief technical description of the proposed treatment system is given below.

Cooling tower blowdown would be routed from the tower basin to a feed tank at the head of each process module. From the feed tank, the effluent would be pumped to a heat exchanger where the temperature of the water would be raised to near the boiling point. The water would then pass through a deaerator for removal of noncondensible gases. From the deaerator, the water would enter the evaporator sump. The water would then be recirculated from the sump to the top of the heat transfer tubes, where it would be released to fall as a film inside the tubes. A portion of the falling film would be vaporized. The vapor would then be compressed and allowed to expand into the shell side of the tube bundle. The temperature differential between the vapor and the brine film would allow the vapor to condense as relatively pure water. The pure water would then be taken from the system for use as either makeup to the condenser circulating water system or makeup to the demineralized water system. The concentrated brine would be continuously withdrawn from the evaporator sump for final disposal. Disposal could consist of ponding of the slurry or deydration to a solid for burial.

Before discharging the blowdown to the process, it would be desirable to concentrate the blowdown stream in order to

minimize the volume processed and the size of process equipment. This would be accomplished by operating the condenser circulating water system at 5 cycles of concentration. Approximately 11 one million gallon-per-day process modules (see figure 10.2.2) would be required per plant in order to operate at 5 cycles of concentration.

Solid residue from the system would be disposed of in an approved landfill. For a typical plant, approximately 765 ft^3 of residue would have to be disposed of daily.

Advantages and disadvantages of the total recycle brine concentration system are summarized below.

Advantages:

1. No discharge of liquid pollutants to unrestricted waterways.
2. Makeup water for demineralized water systems could be supplied from this system, eliminating the need for separate water treatment plants and makeup demineralizers.

Disadvantages:

1. Large capital outlay is required.
2. Operating and maintenance costs are high.
3. There is presently no utility experience with large-scale (i.e., millions of gallons per day) total recycle operation.
4. A solid waste disposal problem still remains.
5. Energy would be consumed.
6. Plant reliability would be reduced.
7. Possible operational problems with 5 cycles of concentration in the towers.

10.2.2.2.2 Sidestream Treatment using Filtration, Softening, Reverse Osmosis, and Evaporation - System Description:

A process flow diagram of the system is given as figure 10.2-3. Cooling water in the tower basins would be treated by sidestream desilting. Raw water taken into the condenser circulating water system as makeup would contain varying amounts of suspended solids of organic and inorganic nature. Water would be diverted from the tower basin through the tower basin desilting outlet, treated with synthetic organic flocculants that add no dissolved salts to the water, and subjected to sedimentation in a Lamella separator. Underflow solids which are primarily silt and vegetable matter would be thickened and filtered.

Operation of the sidestream desilting unit would be independent of other system functions. Hardness would be removed from cooling water by cold lime softening. Hot water from the condensers would be metered to three parallel softener-clarifiers for removal of accumulated hardness (calcium and magnesium) and for alkalinity reduction. In the softening units, lime would be mixed with the water to elevate pH and provide the chemical environment for precipitation of calcium carbonate and magnesium hydroxide. Depending on the temperature and pH, from 20 to 50 percent of the dissolved silica would be adsorbed onto the magnesium hydroxide floc and removed from solution.

Underflow from the softening units would be thickened and recalcined in a multiple hearth or small rotary kiln. Throughput of the lime kiln would be regulated to supply the softening requirements plus suitable lime in inventory for kiln maintenance periods.

The softened water would return to the recirculating system after recarbonation for pH reduction. Carbon dioxide for recarbonation would be available from the kiln flue gases. Thus, once operation of the softener **stage** was initiated, there would be no further need to purchase treatment chemicals from outside sources other than a relatively small amount of sulfuric acid for later treatment stages.

Dissolved ions would be removed by reverse osmosis. Continued recycle and evaporation of water would concentrate certain ions in the water that are normally soluble and do not enter into the softening reactions. These ions (sodium, potassium, chloride, sulfate) are not usually associated with scale formation while in low concentrations. They can, in high concentrations, contribute to higher than desirable levels of corrosivity and in extreme concentration will contribute scale-forming components.

An appropriately sized reverse osmosis unit functions to remove and concentrate over 90 percent of these ions from solution into a small brine stream. The purified permeate would be returned to the cooling water system. The reverse osmosis system would draw its feed from the return softened water line. The feed stream to the reverse osmosis unit would be prefiltered, acidified with sulfuric acid, and passed under pressure through the RO membrane.

The brine concentration or final solidification would be accomplished in a vapor compression or multistage flash evaporator. Underflow sludge from the unit would be dried on a direct contact dryer. Condensate from the evaporation stage would be quite pure and would be used as feed to the boiler water makeup demineralizers.

Depending on flow requirements, distillate and/or reverse osmosis permeate would be demineralized in mixed bed ion exchange units and placed in storage for boiler feed purposes.

Regenerant waste from demineralizers would be metered to the evaporation stage for disposal.

Solid wastes from the process would be disposed of in an approved landfill. For a typical plant, approximately 817 ft^3 of solids would be disposed of daily.

Advantages and disadvantages of this system are described below.

Advantages:

1. By employing use of stages that consider only target ionic species, the feed flows and thus the unit size, capital cost, and operation cost of succeeding stages of treatment are reduced.
2. Capital and operating costs are less than for brine concentration.
3. No chemicals are discharged to surface waters.
4. System would supply makeup water, eliminating the need for separate water treatment plant and makeup demineralizers.

Disadvantages:

1. A total recycle system of this scale has not been installed or operated for treatment of condenser circulating water systems.
2. Total cost is high.
3. Energy consumed.
4. Plant reliability reduced.
5. Possible problems with higher concentration factors.

10.2.3 Evaluation of the Impacts of the Alternative Designs

10.2.3.1 Impacts on Surface Water - The major differences associated with the alternative designs considered are the differences in the quantities of water taken from and discharged to the reservoir and the costs of these designs. The total recycle designs would reduce the total makeup requirements to the plants by about one-half, would eliminate the need to discharge blowdown, and would cost about $40 million. The partial treatment alternative would reduce makeup requirements about one-third, would reduce the blowdown requirements by about two-thirds, and would cost about $11 million. However, the reductions in makeup quantities to the plant would not be expected to result in a significant difference in the design of the intake structure. Since impacts such as fish impingement and entrapment are essentially dependent on the intake design and location rather than the quantities of water taken in, these impacts would not be expected to show a difference which could be measured within the accuracy of the estimate.

Other impacts, however, such as the entrainment of larval fish and plankton are directly related to design and location of the intake as well as the quantities of water taken in. These species are pelagic and are carried into the plant in the makeup water without chance for escape. It is assumed that 100 percent of these biota taken in are killed either due to the mechanical action of pumps or due to the thermal shock of passing through the cooling system. Therefore, these impacts on biota would be 50 percent less for the total recycle alternatives and 33 percent less for the partial treatment than for the proposed direct discharge system. The proposed deepwater intake is expected

to entrain only about 6 percent of the numbers of larval fish that would be entrained by an open channel intake so that use of a total recycle alternative would result in a reduction of potential larval fish entrainment of only 3 percent. Also, it can be assumed that there is a natural mortality rate of 90 percent during the larval fish stage. The total impact of loss of biota for any treatment alternative is not considered to be discernible, however, as the total numbers are small compared to the population present in the immediate area.

As discussed in Section 3.4, thermal discharges from the plant consist only of blowdown from the heat dissipation systems. The total recycle of blowdown would essentially eliminate the thermal discharges from the plant. The partial treatment would result in thermal discharges approximately one-third of those discussed in Section 3.4 for the proposed system. Approximate total areas and volumes within the various isotherms are shown below for each alternative assuming that the thermal plume is proportional to the amount of heat discharged.

	Direct Discharge	Partial Treatment	Total Recycle
Btu/hr discharged	1.24×10^9	0.41×10^9	0
Acres of water surface with $\Delta T > 5^\circ$ F.	0	0	0
Acre-ft of water with $\Delta T > 5^\circ$ F.	14	4.7	0
Acres of water surface with $\Delta T > 3^\circ$ F.	1,000	333	0
Acre-ft of water with $\Delta T > 3^\circ$ F.	20,000	6,667	0
Acres of water surface with $\Delta T > 2^\circ$ F.	1,660	553	0
Acre-ft of water with $\Delta T > 2^\circ$ F.	37,000	12,337	0

The shape of the thermal plume for the partial treatment will be similar to that discussed in section 5.1 for the proposed system and would not be expected to have appreciably smaller impacts since only a very small portion of the reservoir would be affected.

The effects of the discharge plume on dissolved oxygen in the reservoir was evaluated by calculating the expected dissolved oxygen content in the discharge under worst conditions.

When the maximum blowdown temperature occurs, the dissolved oxygen concentrations in the blowdown will be at their lowest levels. It is assumed that the concentration of dissolved oxygen in the blowdown will be at or near the maximum solubility level for the temperature of the blowdown. Shown below are the expected maximum mean monthly blowdown temperature, the solubility of dissolved oxygen at that temperature,(based on an elevation of 445 feet MSL), and the dissolved oxygen concentration representing 80 percent of the solubility value.

Heat Dissipation System	Expected Maximum Mean Monthly Blowdown Temperature °F	Dissolved Oxygen Solubility mg/l	80% of Dissolved Oxygen Solubility mg/l
Natural Draft Towers	85.1	7.5	6.0

This shows that, at dissolved oxygen concentrations of saturation and 80 percent of saturation for maximum blowdown temperatures, the dissolved oxygen concentration of the blowdown will not be less than 5.0 mg/l. Hence, the volume of affected waters with dissolved oxygen concentrations below 5, 3, and 1 ppm will be zero. Therefore, the effluent from any of the blowdown treatment alternatives will not cause the dissolved oxygen concentration of the receiving waters to be below 5.0 mg/l.

The chemical effluents to the reservoir from the cooling systems consist primarily of compounds found in the reservoir, and concentrated due to the evaporation in the system. A tabulation of the compounds found in the reservoir and their typical values are shown in table 10.2-3. Also shown are the comparative values for the effluent from the partial treatment alternative. Table 10.2-4 shows the normal discharge concentrations from the proposed direct discharge system. As discussed in section 3.4, either of these discharges would be mixed with 9 equal parts of reservoir water by the diffuser thus giving lower concentrations in the reservoir. The expected concentrations at the boundary of the 9:1 mixing zones are also shown in the tables 10.2-3 and 10.2-4 for the respective alternative systems. As can be seen from these tables, the partial treatment and the proposed direct discharge system have similar discharge concentrations such that the major advantage to partial treatment would be only a reduction of size of an already small plume.

The small difference between concentrations due to the direct discharge and partial treatment designs and the total recycle design are within the natural fluctuations in the reservoir and none would result in a significant impact on the reservoir environment.

The Old Hickory Reservoir serves as the source of water supply to municipalities, industry, and agriculture. The choice of blowdown treatment systems will not affect the amounts of water available for these or any other uses.

Construction of any of these alternatives would be restricted to the proposed plant site and additional offsite land would not have to be acquired. Also, no significant differences would exist in the amount of erosion and siltation which would occur.

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<u>10.2.3.2 Other Impacts</u> - The alternative designs considered will affect the quantity of makeup water required and the amount and quality of discharge to the Old Hickory Reservoir as discussed above. It will not affect the operation of the cooling systems or any other facilities at the plant. Treatment alternatives would not include ponds, etc., and would be confined to the general area of the main plant buildings. It is therefore concluded that the selection of these alternatives would have no bearing on impacts on ground water, air, or land in the plant locale.

TABLE 10.2.1

	No Treatment* Blowdown to River @ Any Concentration Level	Partial Treatment Magnesium Carbonate Process @ 4 Cycles of Concentration 12M Gal/Day
Costs (two-unit plant)		
Capital (installed 1981)	Less than 2,500,000	3,754,000
Operating and Maintenance Present Worth	210,000	1,773,000
Total (Over Plant Life	2,710,000	5,527,000
CCW System Parameters (Gal/min)		
Evaporation	24,800	24,800
Blowdown	24,800	8,248
Makeup	49,600	33,048
Ions of Total Solids		
Discharge Daily	57.5	17.4
Removed Daily	0	22.9

*The no-treatment system costs reflect the cost of materials procurement, construction, and maintenance of the entire discharge system (i.e., piping, instrumentation, and diffuser) on a per-plant basis.

TABLE 10.2-2

	TOTAL RECYCLE ALT BRINE CONCENTRATION WITH FLASH EVAPORATION OF CONCENTRATE @ 5 CYCLES OF CONCENTRATION	TOTAL RECYCLE ALT FILTRATION, SOFTENING AND REVERSE OSMOSIS OF SIDE-STREAM @ 4 CYCLES OF CONCENTRATION
COSTS (two-unit plant)		
CAPITAL (dollars)	55,080,000	5,250,000
(installed 1981)		
OPERATING AND MAINTENANCE PRESENT WORTH	22,080,000	19,400,000
TOTAL (Over plant Life) (dollars)	77,160,000	24,650,000
CREDIT FOR MAKE-UP WATER (Over plant Life)	2,400,000	2,400,000
TOTAL WITH CREDIT	74,760,000	22,250,000
CCW SYSTEM PARAMETERS (gal/min)		
EVAPORATION GPM	24,800	24,800
BLOWDOWN GPM	6,186	8,248
MAKE-UP GPM	30,986	33,048
POUNDS OF IMPURITIES DISCHARGED DAILY	None	None
SOLID WASTE TO BE DISPOSED OF DAILY CUBIC FEET	765	817

Table 10.2.3

EFFLUENT CONCENTRATIONS

Partial Treatment Alternative

At 4 Cycles of Concentration

	Initial River Concentration ppm (Values are monthly avg. over 7 yrs)	Concentration in CCW System before treatment ppm	Concentration in CCW System blowdown conduit ppm	Concentration in Reservoir at mixing zone boundary
Calcium as $CaCO_3$	55.5	222	114	66.9
Magnesium as $CaCO_3$	27.6	110	45	32.1
Sodium as $CaCO_3$	5.6	22.4	22.4	7.8
Potassium	2.0	8.0	8.0	2.8
Iron as Fe_2O_3	2.1	8.4	8.4	2.9
Manganese	0.2	.8	.8	.3
Silica	5.3	21.2	21.2	7.4
Total Hardness as $CaCO_3$	83.1	332	159	99.0
Total Alkalines as $CaCO_3$	58.75	235	61.1	64.9
Chlorides	6.1	24.4	24.4	8.5
Sulfates	15.9	63.6	63.6	22.3
Phosphates	.6	2.4	2.4	.8
Total Dissolved Solids	88.5	354	209	109.4
Total Suspended Solids	105	420	40	145
Turbidity	22.1 JTU		21 JTU	

Table 10.2.4

NORMAL EFFLUENT CONCENTRATIONS

Direct Discharge Alternative

At 2 Cycles of Concentration

	Concentration from CCW system without treatment ppm	Concentration in reservoir at mixing zone boundary
Calcium as $CaCO_3$	111	66.6
Magnesium as $CaCO_3$	55.2	33.1
Sodium as $CaCO_3$	11.2	6.7
Potassium as $CaCO_3$	4.0	2.4
Iron as Fe_2O_3	4.2	2.5
Manganese	.4	0.2
Silica	10.6	6.4
Total Hardness as $CaCO_3$	166.2	99.7
Total Alkalines as $CaCO_3$	117.5	70.5
Chlorides	12.2	7.3
Sulfates	31.8	19.1
Phosphates	1.2	0.7
Total Dissolved Solids	177	106.2
Total Suspended Solids	210	126

TABLE 10.2-5

COST/BENEFIT TABLE - BLOWDOWN TREATMENT ALTERNATIVES

Alternatives:		Proposed Scheme	Partial Treatment	Total Recycle with Brine Concentration	Total Recycle with Reverse Osmosis
Cost: Present Worth:		3,764,000	11,054,000	82,200,000	44,500,000
Annualized:		323,000	948,000	7,053,000	3,818,000
Incremental Cost:		Base	7,290,000	78,436,000	40,736,000
Environmental Costs	Units	Magnitude	Magnitude	Magnitude	Magnitude
1. Natural Surface Water Body					
1.1 Impingement or entrapment by cooling water intake structure					
1.1.1 Fish		Base	See text	See text	See text
1.2 Passage through or retention in cooling systems					
1.2.1 Phytoplankton and zooplankton	Percent taken in by proposed system	Base	(33)	(50)	(50)
1.2.2 Fish	Percent taken in by proposed system	Base	(33)	(50)	(50)
1.3 Discharge area and thermal plume					
1.3.1 Water quality, excess heat	Acres and acre-feet	See text	See text	See text	See text

TABLE 10.2-5 (Continued)

Environmental Costs	Units	Proposed Scheme	Partial Treatment	Total Recycle with Brine Concentration	Total Recycle with Reverse Osmosis
1. Natural Surface Water Body (Continued)					
1.3.2 Water quality, oxygen availability	Acres and acre-feet <5.0 ppm	Base	0	0	0
1.3.3 Fish, nonmigratory	Acres and acre-feet	See text	See text	See text	See text
1.3.4 Fish, migratory	Acres and acre-feet	See text	See text	See text	See text
1.3.5 Wildlife (including birds, aquatic and amphibious mammals, and reptiles)	Acres and acre-feet	See text	See text	See text	See text
1.4 Chemical effluents					
1.4.1 Water quality, chemical	Acre-feet required for dilution	0	0	0	0
1.4.2 Fish	Pounds	0	0	0	0
1.4.3 Wildlife (including birds, aquatic and amphibious mammals, and reptiles)	Population	0	0	0	0
1.4.4 People	Miles	0	0	0	0
1.5 Radionuclides discharged to water body		No effects	No effects	No effects	No effects

TABLE 10.2-5 (Continued)

Environmental Costs	Units	Proposed Scheme	Partial Treatment	Total Recycle with Brine Concentration	Total Recycle with Reverse Osmosis
1. Natural Surface Water Body (Continued)					
1.6 Consumptive use					
1.6.1 People	Gallons/year	0	0	0	0
1.6.2 Agriculture	Gallons/year	0	0	0	0
1.6.3 Industry	Gallons/year	0	0	0	0
1.7 Plant construction (including site preparation)		No effects	No effects	No effects	No effects
1.8 Net effects	Opinion	See text	See text	See text	See text
2. Ground Water	Opinion	No effects	No effects	No effects	No effects
3. Air	Opinion	No effects	No effects	No effects	No effects
4. Land		No effects	No effects	No effects	No effects

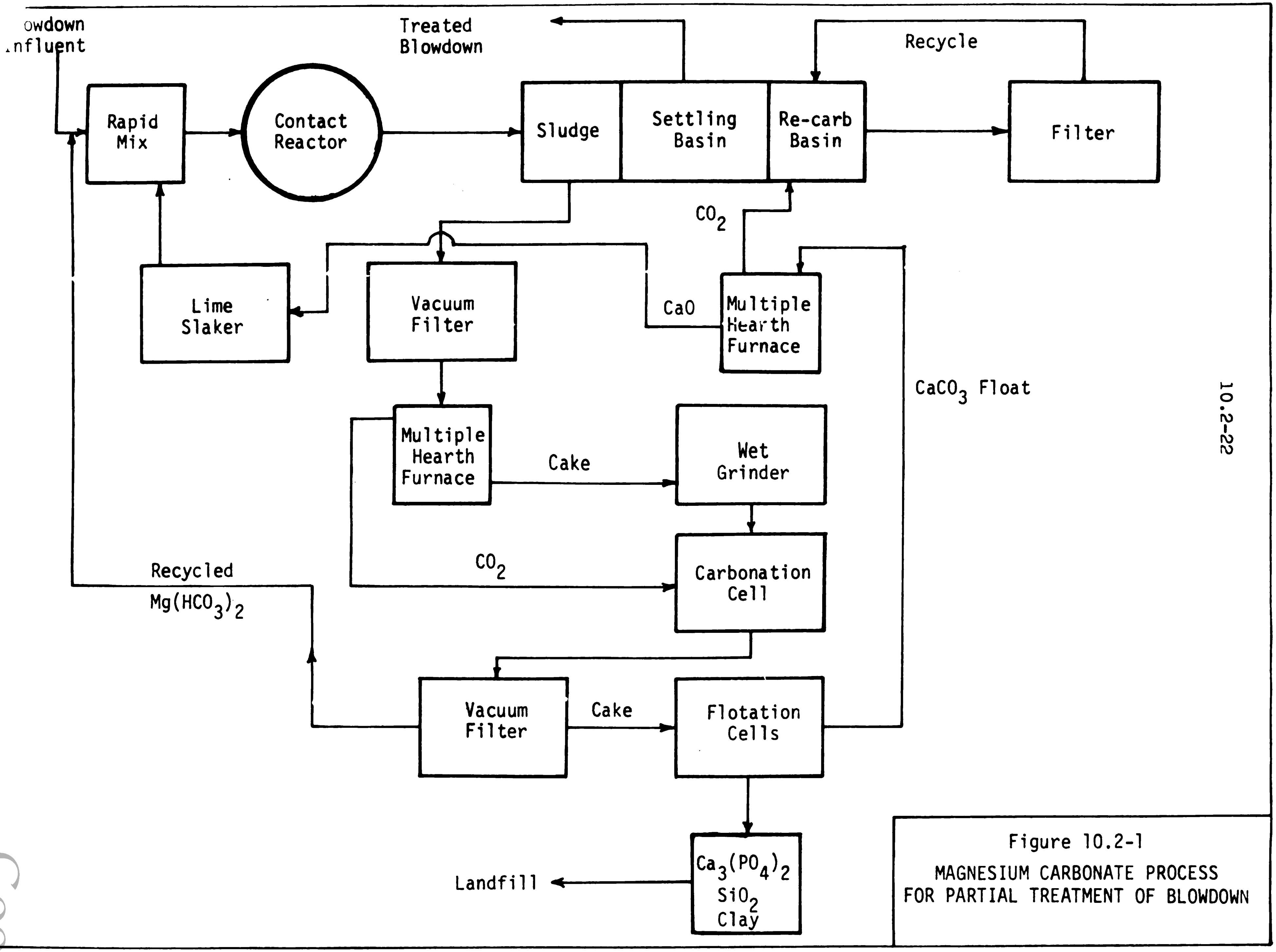

Figure 10.2-1

MAGNESIUM CARBONATE PROCESS FOR PARTIAL TREATMENT OF BLOWDOWN

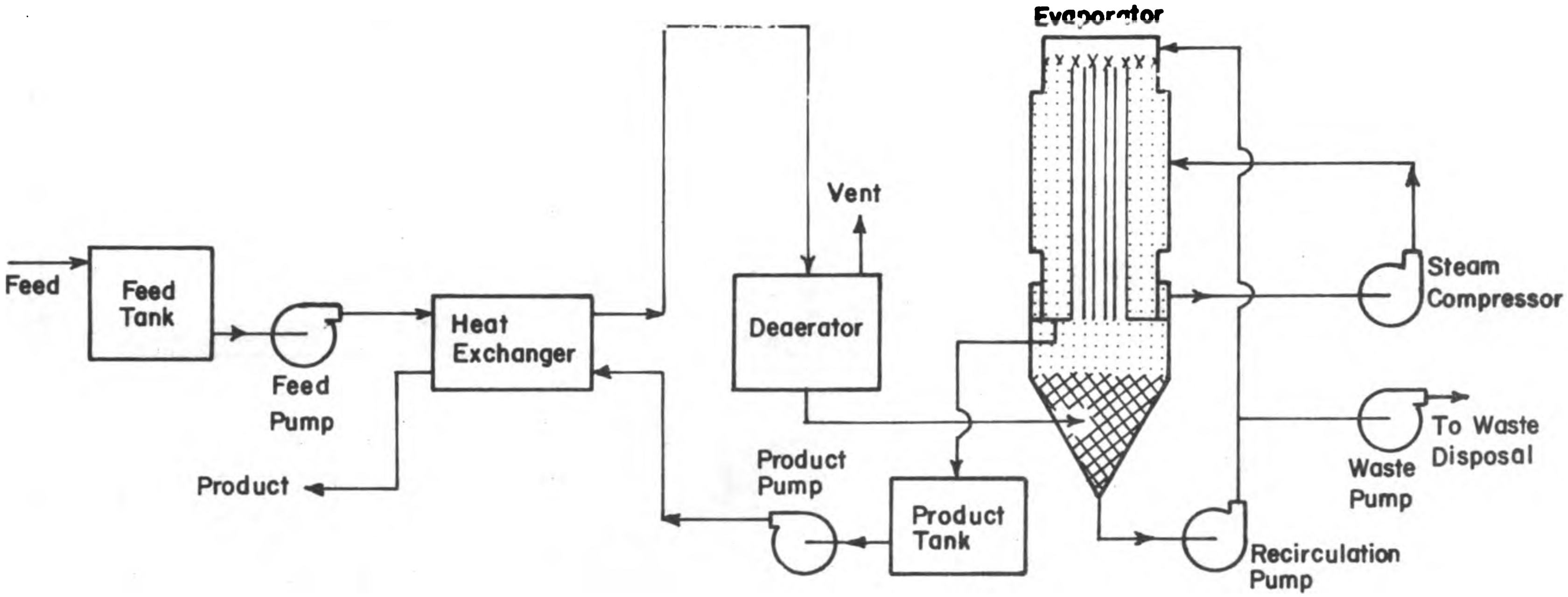

Figure 10.2-2

TOTAL RECYCLE PROCESS BY BRINE CONCENTRATION TYPICAL 1,000,000 GPD MODULE

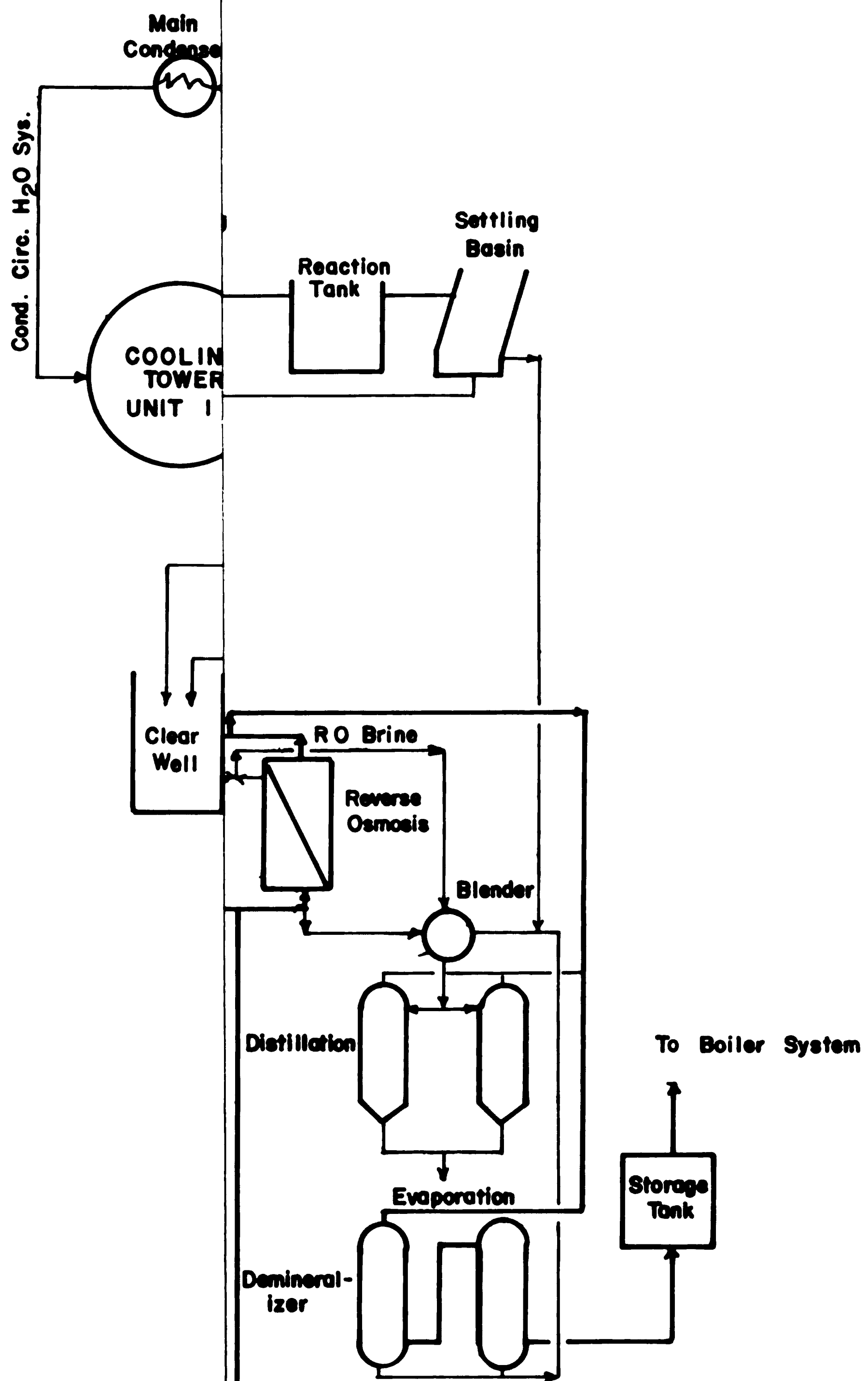

Figure 10.2-3

TOTAL RECYCLE WITH
REVERSE OSMOSIS ALTERNATIVE

10.3 Makeup Water Demineralizer Spent Regenerant Treatment System

10.3.1 Rationale for Selection - Two demineralizer trains per plant, each with a capacity of 180 gallons per minute, would be installed for the purpose of supplying demineralized water for steam systems makeup and other minor plant uses such as equipment decontamination, etc. Both trains will be operated only before unit startup and at times of unit outage which will be for a period of about 12 weeks annually. Normal annual operational requirements should be about 25 percent of maximum treatment capability, based on maximum capacity operation for 12 weeks during refueling and reduced capacity operation for the remaining 40 weeks.

From the review of the benefit/cost inputs for alternatives for regenerant treatment, it is felt that treatment other than pH treatment and discharge via the cooling tower blowdown is not justified. This treatment is a commonly practiced method for industrial facilities and is not thought to be environmentally significant. This waste added to the condenser cooling water system blowdown discharge will not appreciably add to blowdown solids concentrations from that system.

A detailed description of these waste concentrations is contained in section 3.6.3.

The degree of treatment which will ultimately be required by effluent guidelines is unknown. Should treatment of cooling tower blowdown be eventually required, it would seem reasonable that treatment of the blowdown stream could be accomplished at about the same

cost whether or not it contained the spent regenerants. If the treatment of regenerants should be proposed in the future, the design as now proposed would not preclude the addition of these facilities.

A description of this system is given in section 3.6.3.

10.3.2 Alternative Designs - In addition to the proposed treatment method, the evaporation of regenerants with the burial of evaporator bottoms was considered as an alternative design. A comparison of costs and minerals to be treated are shown in table 10.3.1.

The spent regenerants would be collected in a sump until processed by an evaporator. The distillate would be recycled to the treated water clearwell for demineralization and use as demineralized water. The evaporator bottoms would be buried in an approved sanitary landfill.

10.3.3 Assessment of Environment Impacts

10.3.3.1 Impacts on Surface Water Bodies - Evaporating the regenerant wastes would slightly reduce the environmental effects of the facility by eliminating the discharge of regenerant wastes to the reservoir. This system would evaporate the wastes recycling the distillate and dewatering the sludge bottoms to permit burial as solid waste. Recycling the distillate would also reduce the quantity of makeup required for the demineralized water system. This reduction, however, would be miniscule compared to the total water makeup requirements for the plant and the benefits of the reduction as discussed previously would be insignificant. Likewise, the small reduction in discharge will not be discernible in

the discharge area and plume.

The chemicals that would be discharged from the proposed system, the concentrations, and their impacts are discussed in section 3.6. The alternative system would have no impacts on the surface waters since there would be no discharge.

10.3.3.2 Impacts on Ground Water - Impacts the alternative would have on ground water could only occur due to the buried sludge being leaked into the ground water. This sludge would be concentrated before burial so that very little leakage should occur. No significant impacts on the ground water of the area would be expected.

10.3.3.3 Impacts on Air - The alternative system would use a steam source to evaporate the wastes. This steam would be condensed and recycled as condensate so that there would be no discharge to the air.

The concentrated sludge would be buried according to accepted methods and there are expected to be no impacts due to odor, etc., from this burial.

10.3.3.4 Impacts on Land - The alternative system would be built on the proposed plant site so that there would be no additional impacts due to its construction. There will be, however, additional land used to bury the concentrated wastes from this system. There will be approximately 200,000 pounds of solids which will be buried each year along with some entrained water. This would constitute some small impact on land use in the area. Depending on where the landfill was located, impacts on terrestrial biota might be increased slightly.

Table 10.3-1

ALTERNATIVE TREATMENT METHODS FOR SPENT REGENERANTS

	Proposed		Evaporation with Burial of Evaporator Bottoms
Costs (dollars)			
Capital (installed 1981)			1,387,000
Present worth Operating and Maintenance			705,000
Total			2,092,000
Byproducts Produced	Maximum Daily	Average Annual	Same as Proposed
	(pounds per 2-unit plant)		
Sodium Na+	650	59,300	
Sulfate SO_4	1,410	123,600	
Minerals Removed From Treated Water			Same as Proposed
Sodium Na+	24	2,047	
Sulfate SO_4	64	5,750	
Chloride Cl	68	5,074	
Total Dissolved Solids (minerals)	351	32,000	
Total Dissolved Solids	2,411	214,900	

TABLE 10.3-2

COST/BENEFIT TABLE - DEMINERALIZER REGENERANTS TREATMENT

		Proposed	Evaporation
Cost: Present Worth:		96,000	4,194,000
Annualized:		8,200	360,000
Incremental Cost:		Base	4,098,000

Environmental Costs	Units	Magnitude	Magnitude
1. Natural Surface Water Body			
1.1 Impingement by cooling water intake		See text	See text
1.2 Passage through or retention in cooling systems		Base	See text
1.3 Discharge area and thermal plume		Base	No discharge
1.4 Chemical effluents			
1.4.1 Water quality, chemical		See text	No discharge
1.4.2 Fish		See text	No discharge
1.4.3 Wildlife (including birds, aquatic and amphibious mammals, and reptiles)		See text	No discharge
1.4.4 People		See text	No discharge

TABLE 10.3-2 (Continued)

	Environmental Costs	Units	Proposed	Evaporation
1.5	Radionuclides discharged to water body		N/A	N/A
1.6	Consumptive use			
	1.6.1 People	Gallons/year	0	0
	1.6.2 Agriculture	Gallons/year	0	0
	1.6.3 Industry	Gallons/year	0	0
1.7	Plant construction (including site preparation)		No effects	No effects
1.8	Other impacts		No effects	No effects
1.9	Combined or interactive effects		N/A	N/A
1.10	Net effects	Opinion	See text	See text
2.	Ground Water			
2.1	Raising/lowering of ground water levels		0	0
2.2	Chemical contamination of ground water (including salt)		No effects	No effects
2.3	Radionuclide contamination of ground water		N/A	N/A
2.4	Other impacts on ground water		N/A	N/A

TABLE 10.3-2 (Continued)

	Environmental Costs	Units	Proposed	Evaporation
3.	Air			
3.1	Fogging and icing (caused by evaporation and drift)		N/A	N/A
3.2	Chemical discharge to ambient air		N/A	N/A
3.3	Radionuclides discharged to ambient air and direct radiation from radioactive materials		N/A	N/A
3.4	Other impacts on air		N/A	N/A
4.	Land			
4.1	Site selection			
	4.1.1 Land, amount	Acres	Base	See text
4.2	Construction activities (including site preparation)	Opinion	No effects	No effects
4.3	Plant operation			
	4.3.1 People (amenities)	Decibels	Acceptable	Acceptable
	4.3.2 People (aesthetics)	Opinion	Acceptable	Acceptable
	4.3.3 Wildlife		See text	See text
4.4	Salts discharged from cooling towers		N/A	N/A
4.5	Transmission route selection		N/A	N/A
4.6	Transmission facilities construction		N/A	N/A

TABLE 10.3-2 (Continued)

	Environmental Costs	Units	Proposed	Evaporation
4.7	Transmission line operation		N/A	N/A
4.8	Other land impacts		No effects	No effects
4.9	Combined or interactive effects		No effects	No effects
4.10	Net effects	Opinion	See text	See text

10.10

10.11

10.4

10.5

10.6

10.7

10.8

10.9

10.4 Water Treatment Plant Sludges

Raw water will be processed through a filtration plant for providing water to the makeup demineralizers and other plant uses. The plant will have a net capacity of 486 gallons per minute for a daily net output of 635,000 gallons. This rate would be utilized only before unit startup and at times of unit outage which will be for a period of about 12 weeks annually. Annual operational requirements would be about 40 percent of the maximum capacity. Operation of the water filtration plant will require the use of alum, soda ash, and chlorine. Chlorine would be fed only to meet the initial raw water demand. The resultant chlorides would be removed by the makeup demineralizers and would be retained as combined chlorides in the demineralizer regenerant solutions. Filter backwash water and clarifier sludge will contain aluminum hydroxide floc and settled solids.

10.4.1 Rationale for Selection - The review of the benefit/cost information for these alternatives indicates that the microsolids separation alternative is the preferred system from both an economic and environmental standpoint. This system is substantially less expensive than the sand bed alternative and the lagoons. Environmentally, the microsolids separation system is favorable because of the certainty of no discharge of sludge and the smaller requirements for burial of waste generated due to the higher concentrating factor of this process. (This process produces approximately one-fourth the volume of sludge that the sand bed alternative does and less than 10 percent the amount of the lagoon.)

10.4.2 Alternative Designs

10.4.2.1 Drying of Sludge on Sand Beds - The aluminum hydroxide floc would be pumped to one of five concrete-lined sand beds. Each sand bed would consist of 625 square feet of surface area and have 6 to 9 inches of sand on top of the bed, with a filter bottom consisting of 6 to 12 inches of 1/4- to 1/8-inch graded gravel. The sludge would be deposited on top of the sand and the water would percolate through the sand and be collected by underdrains in the filter bottom. The effluent from the underdrain system would be recycled to the water filtration plant inlet when there is a demand. The beds would be covered by a shelter to prevent rainfall from diluting the sludge. It would take 3 to 5 days to concentrate the sludge to 20 percent by weight. After drying, the sludge and a thin layer of sand would be scraped off and buried in an approved sanitary landfill.

10.4.2.2 Sludge Lagooning - The aluminum hydroxide sludge would be pumped from the sludge sump in the Makeup Water Treatment Plant to one of two 110 feet long by 12 feet wide by 8 feet deep sludge settling basins. The two basins would be used alternately for storage and settling. Each basin would be sized for maximum plant output to allow a settling time of 2 days for normal backwash rates and 4 weeks' storage of anticipated sludge. The supernatant water from the lagoon area would be decanted and returned to the inlet of the water filtration plant. As necessary, the sludge would be removed and disposed of by burial in compliance with applicable standards.

10.4.3 Evaluation of Impacts

10.4.3.1 Impacts on Surface Waters - Neither the sand bed filter alternative nor the lagoon alternative would normally discharge to the environment but would discharge back to the water treatment plant and be treated. This is a similar design to the proposed system. This would result in zero discharge to the surface waters from this source and therefore there would be zero impacts on the receiving surface water bodies due to chemicals, etc.

Construction of the sand bed filters would require the disturbance of more land than the proposed system as would the construction of the lagoons. However, the areas required for any of the alternative systems would be located within the proposed plant construction area and construction of any of the alternative discussed would not be expected to increase construction impacts to any significant degree.

10.4.3.2 Impacts on Ground Water - Both the sand bed alternative and the lagooning alternative would be designed to have lined filters and basins respectively. This would eliminate the possibility of leaching out pollutants into the ground water and prevent any possible associated effects. These designs would be equal in effect on ground water due to the proposed system of handling the sludges.

10.4.3.3 Impacts on Air - Neither of the alternative designs would discharge chemicals as such to the air. However, the sand filters

and the lagoons would be open to the atmosphere and it is expected that odors could result from bacteria, etc., growing in the sludge. Being open to the atmosphere, the odors could create an unpleasant effect on the immediate area.

10.4.3.4 Impacts on Land - As previously noted, the sand bed and lagoon alternatives would require more land area than the proposed system for construction. However, all of this land would be within the proposed plant boundary so that the purchase of additional land would not be required.

The open sand beds or lagoons would be considered less acceptable aesthetically because of the open pit design of these alternatives and the nature of the slurries being processed. The proposed system, however, is essentially enclosed and should not create adverse aesthetic impacts.

It is expected that the open sand pits and lagoons would be fenced for safety and to keep out large animals, but this fencing would not prevent small mammals, birds, etc., from reaching the water in the pits.

Both of the alternative designs would, however, have additional land requirements for the disposal of the wastes. The sand bed alternative produces a sludge containing approximately 20 percent solids by weight while the lagoon would produce a sludge containing only about 6 to 8 percent solids. This would require the burial of about 6300 cubic feet of sludge annually for the sand

filter and approximately 15,600 cubic feet of sludge for the lagoons. Assuming a burial thickness of about 3 feet, this would affect areas of approximately 3.5 and 10.5 acres respectively for the two alternatives as compared to less than one acre for the proposed system.

TABLE 10.4-1

TREATMENT ALTERNATIVES FOR WATER TREATMENT PLANT SLUDGE
(Per 2-Unit Plant)

	1A SAND BED DRYING		1B MICROSOLIDS SEPARATION		1C LAGOON
COSTS/PLANT					
CAPITAL (dollars) (installed 1981)	182,000		118,000		117,000
PRESENT WORTH OPERATING AND MAINTENANCE	145,000		19,000		99,000
TOTAL	327,000		137,000		216,000
CHEMICALS USED IN CLARIFICATION	Maximum Daily Pounds	Average Annual Pounds	Maximum Daily Pounds	Average Annual Pounds	
$Al_2(SO_4)_3$	291.5	57,526	Same as 1A		Same as 1A
Na_2CO_3	105.0	20,712			
WASTE PRODUCED					
Al OH$_3$	133	26,227			
SUSPENDED SOLIDS	525	83,522	Same as 1A		Same as 1A
H_2O	29,600	4,709,064			
TOTAL	30,258	4,818,813			
CONCENTRATION OF SLUDGE AFTER TREATMENT, BY WEIGHT	20%		80%		6-8%
CU FT OF SLUDGE BURIED ANNUALLY	6,271		1,568		~15,680

TABLE 10.4-2

COST/BENEFIT TABLE - WATER TREATMENT PLANT SLUDGE TREATMENT

			Proposed	Sand Beds	Lagoon
		Alternatives:	Proposed	Sand Beds	Lagoon
Cost:		Present Worth:	274,000	654,000	432,000
		Annualized:	24,000	56,000	38,000
		Incremental Cost:	Base	380,000	158,000

Environmental Costs		Units	Magnitude	Magnitude	Magnitude
1.	Natural Surface Water Body				
1.1	Impingement or entrapment by cooling water intake structure		N/A	N/A	N/A
1.2	Passage through or retention in cooling systems		N/A	N/A	N/A
1.3	Discharge area and thermal plume		N/A	N/A	N/A
1.4	Chemical effluents		See text	See text	See text
1.5	Radionuclides discharged to water body		N/A	N/A	N/A
1.6	Consumptive use				
1.6.1	People	Gallons/year	0	0	0
1.6.2	Agriculture	Gallons/year	0	0	0
1.6.3	Industry	Gallons/year	0	0	0
1.7	Plant construction (including site preparation)		Base	See text	See text

TABLE 10.4-2 (Continued)

Environmental Costs	Units	Proposed	Sand Beds	Lagoons
1. Natural Surface Water Body (Continued)				
1.10 Net effects	Opinion	See text	See text	See text
2. Ground Water		See text	See text	See text
3. Air		Base	See text	See text
4. Land				
4.1 Site selection				
4.1.1 Land, amount	Acres	Base	See text	See text
4.2 Construction activities (including site preparation)		Base	See text	See text
4.2.1 Land (erosion)	Tons	Base	See text	See text
4.3 Plant operation				
4.3.1 People (aesthetics)	Opinion	Acceptable	Less acceptable	Less acceptable
4.3.2 Wildlife	Opinion	Base	See text	See text
4.4 Salts discharged from cooling towers		N/A	N/A	N/A
4.5 Transmission route selection		N/A	N/A	N/A
4.6 Transmission facilities construction		N/A	N/A	N/A
4.7 Transmission line operation		N/A	N/A	N/A
4.8 Other land impacts				
4.8.1 Land for disposal	Acres	Base	2.5	9.5
4.10 Net effects	Opinion	See text	See text	See text

10.5 Raw Cooling Water Biocide Treatment System

A biocide agent is required to control the growth of fouling organisms in the water systems. A mechanical tube cleaning system will be installed to help prevent fouling of the main condenser; however, TVA experience has shown that mechanical tube cleaning alone is not an acceptable alternative to chemical treatment. In addition, small cooling systems such as the Raw Cooling Water system and the Essential Service Water systems are not equipped with the mechanical cleaning equipment. It was therefore necessary to utilize a chemical-type biocide to maintain the condition of the raw cooling water systems.

10.5.1 Rationale for Selection - TVA has investigated four possible alternatives for control of fouling organisms in plant cooling water systems. The four possible alternatives considered were: generation and injection of chlorine as sodium hypochlorite, injection of diluted gaseous chlorine, injection of acrolein, and generation and injection of ozone.

After a review of the benefit/cost analyses, chlorine treatment appears more desirable than acrolein or ozone treatement. Ozone costs are prohibitive, and the reliability of production methods is uncertain. Hypochlorite is a proven slimicide, as is chlorine, whereas acrolein is not acceptable as a slimicide, and ozone is unproven. Acrolein was unfavorable from an economic standpoint. Properly used, all alternatives considered are environmentally acceptable.

Of the chlorine alternatives, it was agreed that the sodium hypochlorite is the preferred design for the following reasons.

1. Sodium hypochlorite is much safer to handle and use than is chlorine gas. This was a major consideration.
2. It is slightly cheaper than chlorine gas.
3. Although the chlorine gas feeding system is simpler, the hypochlorite generator is considered reliable.
4. Environmental impacts are considered to be essentially equal for these two alternatives as the chlorine is environmentally the most active agent in either design. The slight amounts of sodium chloride and other impurities added with the hypchlorite are felt to have insignificant environmental effects.

10.5.2 Alternative Designs - The following designs were considered as alternatives to the proposed design.

10.5.2.1 Gaseous Chlorination - This process involves producing gaseous chlorine by vaporizing liquid chlorine which is stored in a railroad tank car. Evaporators are provided to insure there is enough heat for complete vaporization of the chlorine. The chlorine gas is then metered, diluted with raw water, and injected into the cooling system. A schematic drawing showing the gaseous chlorination system is presented as figure 10.5-1. The advantages of using gaseous chlorine as a biocide are:

1. Gaseous chlorine has proven to be an effective and reliable biocide.
2. Most waste products can be removed by aeration and dechlorination with sodium bisulfite.

The disadvantages are:

1. The process is not as economical as hypochlorite generation.

2. Liquid chlorine is becoming increasingly in short supply and price increases are expected.

2. Storage and transportation of large volumes of liquid chlorine are becoming less desirable from a safety standpoint.

10.5.2.2 Acrolein -

System Description:

Acrolein is an unsaturated aldehyde which acts as a nonoxidizing biocide. Acrolein would be purged from compressed gas cylinders with nitrogen. It would then be metered and injected into cooling water systems. The acrolein concentration in the tower basins would be below detectable limits after aeration in the towers. This means that, if blowdown is suspended for 30 minutes, there would be no detectable acrolein in the receiving stream.

The advantages of using acrolein as a biocide are:

1. No oxidizing reactions with condenser tube or heat exchanger materials.

2. Substantially all toxicity is removed by aeration in cooling towers.

The disadvantages are:

1. Acrolein has not been used to control fouling in cooling water systems.

2. Cost of chemical is high compared with hypochlorite or liquid chlorine.

3. From a safety standpoint, acrolein is more hazardous to operating personnel than hypochlorite.

A sketch of this system is shown in figure 10.5-2.

10.5.2.3 Ozone Generation -

System Description:

Ozone is a highly oxidizing gas which is quite unstable. It is produced in an ozonator by passing air through a silent electric discharge. The ozone is so unstable that is cannot be generated and stored before use. Ozone from the ozonator would be injected directly into the condenser circulating water system. Residual ozone can be removed by aeration in the cooling tower.

The advantages of using ozone as a biocide are:

1. All residual ozone can be removed by aeration in the cooling tower.
2. Raw materials required for production are inexpensive and in abundant supply.

The disadvantages are:

1. High capital and operating costs.
2. Ozone has not been used as a biocide in cooling water systems.
3. Ozone is a highly oxidizing agent, and its effect on condenser tubes and heat exchange materials has not been determined.
4. Possible adverse air quality effects.

Capital costs shown are based on use of horizontal plate-type ozonators.

A sketch of this system is shown in figure 10.5-3.

10.5.3 Evaluations of the Environmental Impacts

10.5.3.1 Impacts on Surface Water Bodies - The use of any of the biocide alternatives is not expected to have any significant effect on surface water bodies. The discharge from systems being treated will be shut off during periods of treatment until the biocide levels have been reduced to an acceptable level. Use of chlorine would result in the addition of a small amount of chlorides to the water, but the increase

would be within natural fluctuations and well within appropriate guidelines, (see table 10.5.1). Ozone and acrolein would be removed by demand and scrubbing in the cooling systems and would not be discharged to the reservoir. Therefore, there should be no effect on the biota populations in the reservoir or to human uses of the reservoir waters due to the use of biocides in the cooling systems.

Construction of any of the alternative system facilities will take place within the prescribed area of the plant construction and will not require additional land. Therefore, the construction of these facilities should not create additional problems related to erosion, siltation, etc., which would affect the surface waters of the plant environment.

<u>10.5.3.2 Effects on Ground Water</u> - All of the cooling water systems to be treated with chemical biocides are designed with lined ponds, etc., so that seepage from the system will not enter the ground water. In the event of a leak in one of the systems, it is expected that the natural biocide demand of the soil and ground water will remove any trace of the biocide before it could reach the reservoir. There are no existing or planned wells between the plant and the reservoir which might be affected.

A small amount of water will be blown out of the cooling towers as drift. This drift is expected to deposit within 2,000 feet of the towers as discussed in section 3.4.

<u>10.5.3.3 Impacts of Air</u> - Effects of biocide treatment on the air result from the release of the compounds to the air by the scrubbing effects of the cooling towers.

Only 1 percent of the daily gaseous chlorine treatment would be extected to be released to the air. Emission concentrations were calculated for the biocide alternatives. These are shown in table 10.5-2.

According to the Environmental Protection Agency and the Tennessee Air Pollution Control Agency, there are no emission standards for chlorine, acrolein, or ozone. There is a 1-hour ambient air standard of 0.08 ppm for ozone.

The small emission concentrations for chlorine would be insignificant. The emission concentrations for acrolein would be below the industrial hygiene standard by a factor of about 2 or 3. Estimated ambient ground-level concentrations would be still smaller by at least an order of magnitude.

Ozone would present the greatest potential for significant impact.

10.5.3.4 Impacts on Land - The equipment for the biocide alternatives would be contained within the prepared plant. Therefore, there will be no difference in effects due to requirements for additional land, additional construction, etc. The only difference in impacts on land will be those resulting from the effects of drift depositing on the land around the plant and biocide material discharged to the air and affecting terrestrial life. The low concentrations of the biocides leaving the towers and the short times of their use will result in insignificant effects due to this discharge.

Table 10.5-1

Discharge Concentrations (mg/l)	Alternatives: Hypochlorite (Proposed System) Free Chlorine	Hypochlorite (Proposed System) Chlorides	Hypochlorite (Proposed System) Total Dissolved Solids	Chlorine Gas Free Chlorine	Chlorine Gas Chlorides	Chlorine Gas Total Dissolved Solids	Acrolein	Ozone
River Concentrations								
Average	-	6.1	88.5	-	6.1	88.5		
Maximum	-	24	158	-	24	158		
Contribution of Impurity to Blowdown	.000	0.3	0.6	.0	0.17	0.34	Acrolein is removed by aeration	Ozone is removed by Aeration
Concentration in CCW Blowdown Conduit								
Average	-	12.5	177.6	.0	12.4	177.4		
Maximum	-	48.3	316.6	.0	48.2	316.4		
Concentration in River After Mixing								
Average	-	6.7	97.4	.0	6.7	97.4		
Maximum	-	26.4	173.8	.0	26.4	173.8		
Maximum Allowable Stream Limit	.1	250	500	.1	250	500		

TABLE 10.5-2

COST/BENEFIT TABLE - BIOCIDE TREATMENT SYSTEM

		Proposed	Chlorine Gas	Acrolein	Ozone
Alternatives:		Proposed	Chlorine Gas	Acrolein	Ozone
Cost: Present Worth:		900,000	1,020,000	2,674,000	16,600,000
Annualized:		77,200	87,500	229,400	1,424,000
Incremental Cost:		Base	120,000	1,774,000	15,700,000
Environmental Costs	**Units**	**Magnitude**	**Magnitude**	**Magnitude**	**Magnitude**
1. Natural Surface Water Body					
1.1 Impingement of entrapment by cooling water intake structure					
1.1.1 Fish		N/A	N/A	N/A	N/A
1.2 Passage through or retention inccooling systems		See text	See text	See text	See text
1.3 Discharge area and thermal plume		N/A	N/A	N/A	N/A
1.4 Chemical effluents					
1.4.1 Water quality, chemical	Acre-feet	Base	0	0	0
1.4.2 Fish		See text	See text	See text	See text
1.4.3 Wildlife (including birds, aquatic and amphibious mammals, and reptiles)		See text	See text	See text	See text
1.4.4 People	Days	Base	0	0	0

TABLE 10.5-2 (Continued)

Environmental Costs	Units	Proposed	Chlorine Gas	Acrolein	Ozone
1. Natural Surface Water Body (Continued)					
1.5 Radionuclides discharged to water body		N/A	N/A	N/A	N/A
1.6 Consumptive use					
1.6.1 People		0	0	0	0
1.6.2 Agriculture		0	0	0	0
1.6.3 Industry		0	0	0	0
1.7 Plant construction (including site preparation)		No effects	No effects	No effects	No effects
1.8 Net effects	Opinion	See text	See text	See text	See text
2. Ground Water					
2.1 Raising/lowering of ground water levels		N/A	N/A	N/A	N/A
2.2 Chemical contamination of ground water (including salt)					
2.2.1 People		0	0	0	0
2.2.2 Plants		0	0	0	0
2.3 Radionuclide contamination of ground water		N/A	N/A	N/A	N/A

10.6 | 10.7 | 10.8 | 10.9 | 10.10 | 10.11 | 10.12

TABLE 10.5-2 (Continued)

Environmental Costs	Units	Proposed	Chlorine Gas	Acrolein	Ozone
3. Air					
3.1 Fogging and icing (caused by evaporation and drift)		N/A	N/A	N/A	N/A
3.1.1 Ground transportation		N/A	N/A	N/A	N/A
3.1.2 Air transportation		N/A	N/A	N/A	N/A
3.1.3 Water transportation		N/A	N/A	N/A	N/A
3.1.4 Plants		N/A	N/A	N/A	N/A
3.2 Chemical discharge to ambient air					
3.2.1 Air quality, chemical	lbs/yr	0	528	24,077	76,200
3.2.2 Air quality, odor	Opinion	No effects	No effects	No effects	No effects
3.3 Radionuclides discharged to ambient air and direct radiation from radioactive materials		N/A	N/A	N/A	N/A
4. Land					
4.1 Site selection					
4.1.1 Land, amount		No effects	No effects	No effects	No effects
4.2 Construction activities (including site preparation)		No effects	No effects	No effects	No effects

TABLE 10.5-2 (Continued)

Environmental Costs	Units	Proposed	Chlorine Gas	Acrolein	Ozone
4. Land (Continued)					
4.3 Plant operation					
4.3.1 People (amenities)		No effects	No effects	No effects	No effects
4.3.2 People (aesthetics)		No effects	No effects	No effects	No effects
4.3.3 Wildlife		See text	See text	See text	See text
4.4 Salts discharged from cooling towers					
4.4.1 People		See text	See text	See text	See text
4.4.2 Plants and animals		See text	See text	See text	See text
4.4.3 Property resources		See text	See text	See text	See text
4.5 Transmission route selection		N/A	N/A	N/A	N/A
4.6 Transmission facilities construction		N/A	N/A	N/A	N/A
4.7 Transmission line operation		N/A	N/A	N/A	N/A
4.8 Net effects	Opinion	See text	See text	See text	See text

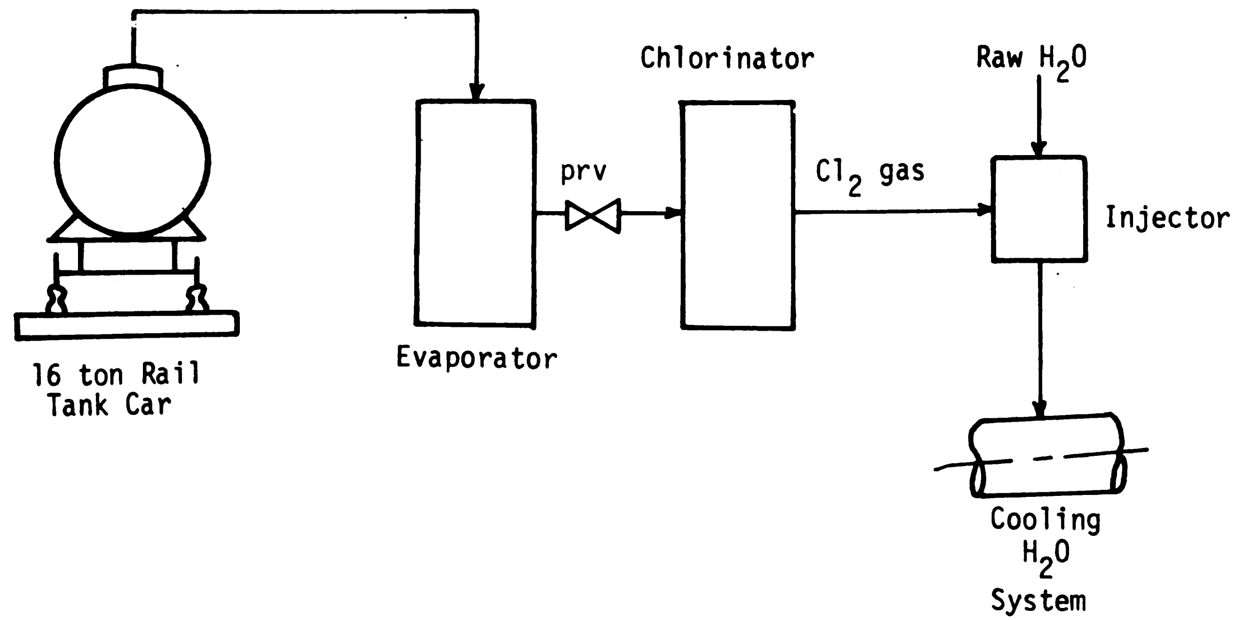

Figure 10.5-1

GASEOUS CHLORINATION

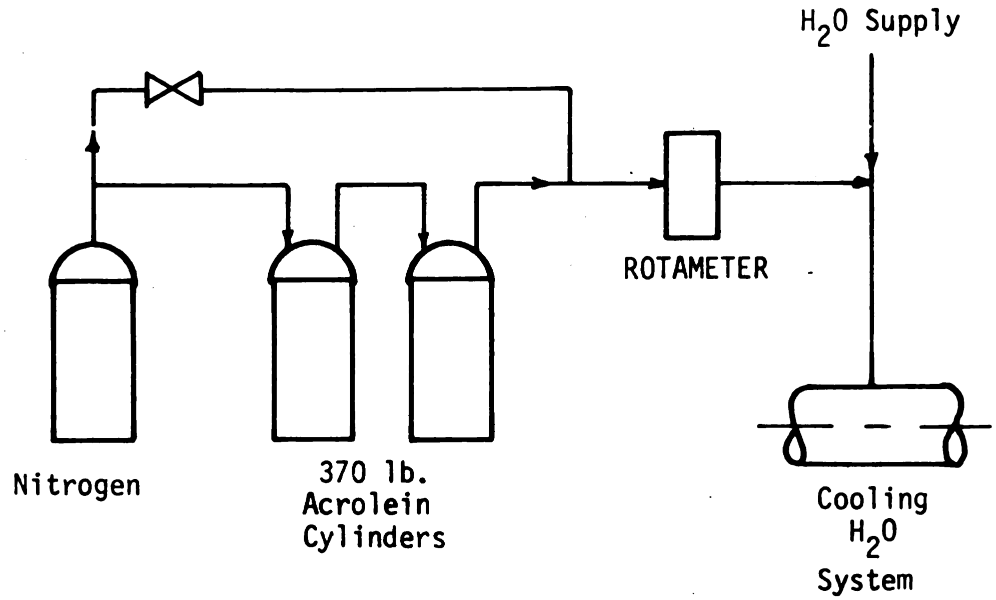

Figure 10.5-2

ACROLEIN TREATMENT

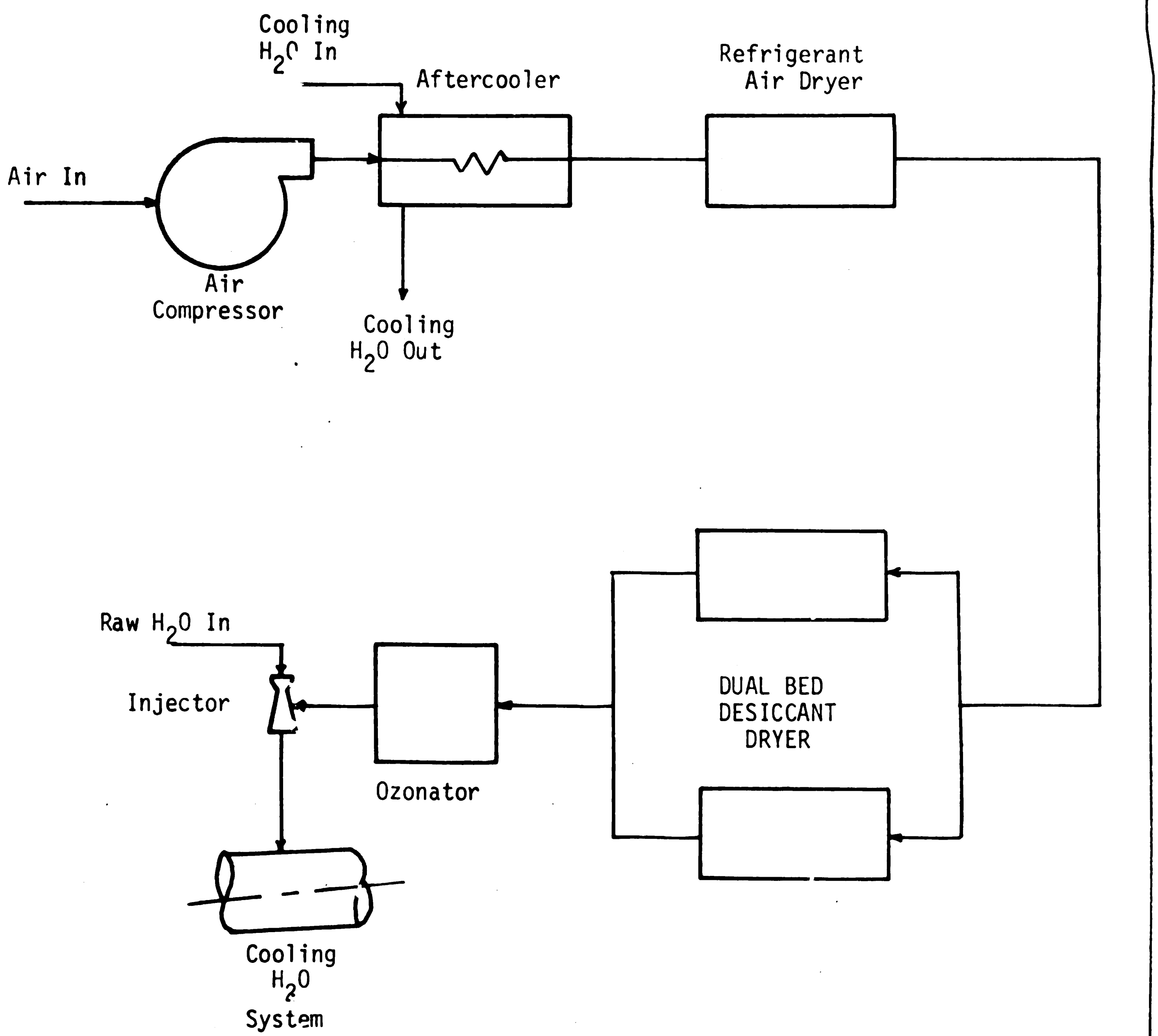

Figure 10.5-3

OZONE GENERATION

10.6

10.6 Sanitary Waste Treatment System

It is proposed that there be one sanitary waste treatment facility per plant for the Hartsville Nuclear Plant complex. Each proposed sanitary waste system is sized to accommodate the needs of approximately 350 persons (per plant). This results in a system capacity of approximately 12,000 gallons per day (35 gallons per person per day). Three types of treatment systems were evaluated: subsurface drain fields, sand filters, and extended aeration.

10.6.1 Rationale for Selection - The review of the **benefit/cost** analyses for this group of alternatives reveals several areas which require additional considerations. These areas deal primarily with the reliability of the systems and the possible effects of this on plant operation and cost. All three systems considered are felt to have similar environmental effects; however, the subsurface drain field, which is the lowest cost alternative, is felt to have some drawbacks.

The following items are considered as deterrents to adoption of the drain field alternative:

1. Repairs to a disposal field of this size in the event of pluggage would present an extensive problem; in fact, in many cases, it might require complete abandonment.
2. The area required for the drain field would have very limited use since it would not accommodate heavy vehicles.
3. Because of questions regarding percolation rates, only certain areas would be acceptable, and these may not be conveniently located.
4. Care has to be taken to avoid ponding, i.e., water standing on a disposal field, since this would destroy its use as a disposal field.

5. Proper construction of a field of the required size would be difficult because of the need for having evenly distributed flow through all of the many field lines. This distribution is difficult to achieve in a gravity flow system such as this. If uneven flow resulted, portions of the fields would become overloaded and the entire field could become inoperative.

Based on the small cost advantage of the drain field over other treatment systems and the other factors identified, TVA feels the drain field should be ruled out in favor of one of the more reliable alternatives.

There is significant possibility that the drain field could become plugged and complete replacement would be required. It was expected that this replacement, which is not reflected in the operating and maintenance costs, would nullify any economic benefits of the field.

A review of the sand bed filter alternative and the extended aeration package plant alternative benefit/cost analysis does not show any appreciable benefits of the sand filter over the less expensive package plant.

While it was recognized that the package plant would require more operator attention, this commitment of manpower is already reflected in O&M costs and is included in the benefit/cost analysis. It is felt that experience with the package plant at other TVA facilities and at other industrial facilities is sufficient to judge the package plant to be a suitable and reliable system for this application.

TVA believes that the extended aeration package plant is the optimum design considering economic costs, reliability, and environmental impacts for use at the Hartsville Nuclear Plant complex.

10.6.2 Alternative Designs - In addition to the proposed system, two alternative designs were evaluated for use at the proposed plant. Discussions of each of these alternatives are presented below.

10.6.2.1 Subsurface Drain Field -

System Description:

This system would consist of a 12,000-gallon septic tank, a 1,500-gallon dosing tank, two dosing siphons, and two 12,600-ft^2 subsurface drain fields. A schematic diagram of this system is shown in figure 10.6-1.

The waste treatment process would be initiated by routing plant sanitary wastes to the septic tank where it would be subjected to anaerobic bacterial action. Liquid effluent would be drained from the septic tank to the dosing tank. The contents of the dosing tank would be discharged on a cyclic basis by automatic siphoning action to alternate drain fields. An assumed percolation rate of 20 minutes per inch was used to size the drain field. Each drain field would have approximate dimensions of 95 feet by 132 feet. Each field would have 44 drain lines, 95 feet in length.

10.6.2.2 Sand Filter -

System Description:

This system would consist of a 12,000-gallon septic tank, 1,000-gallon dosing tank with two dosing siphons, a 12,000-ft^2 sand

filter, and a 2,500-gallon chlorine contact tank. A schematic diagram of the system is shown in figure 10.6.1.

Waste processing would begin with sanitary wastes being routed from the plant to the 12,000-gallon septic tank. The wastes would be subjected to aerobic action in the septic tank. Liquid from the septic tank would be routed to the dosing tank. Once the dosing tank is filled, the contents would be discharged by automatic siphoning action to the sand filter. From the sand filter, the filtrate would be collected and chlorinated. The treated effluent would then be released to the condenser circulating water system blowdown line.

The system would be capable of removing 90 percent of the suspended solids and 5-day BOD.

10.6.3 Evaluations of Impacts

10.6.3.1 Impacts on Surface Water Bodies - The primary impact to surface water bodies from sanitary waste treatment system alternatives would be from the amounts of chemicals and biological material discharged into the receiving stream. The subsurface drain field design would discharge to surface water bodies only by way of seepage through the overburden into the groundwater and to the reservoir. Sufficient overburden exists at the site, however, to treat the wastes sufficiently to assure that there would not be any chemicals or other harmful matter reaching the groundwater or the reservoir. The sand filter design would remove 90 percent of the suspended solids and 5-day BOD with the effluent being chlorinated. Amounts of materials which would be discharged from each alternative are shown in Table 10.6-1. The volume of

discharges from these alternatives would be about 24,000 gallons per day maximum. The amount and concentrations of chemical, etc., discharged would be within limits required by the NPDES permit and would not have a detectable effect on the water quality of the reservoir for any present or projected use, nor any impact on the aquatic biota and other life using the reservoir habitat.

Construction of either alternative design would require disturbances of more land than the proposed system. However, this disturbance will be within the general construction area of the plant and would cause little additional siltation or otherwise disturb the surface water bodies.

10.6.3.2 Impacts on Groundwater - The subsurface drainfield design is the only alternative design which could affect groundwater in the area as the sand bed design and the proposed system would discharge to the reservoir as point discharges and could not enter the groundwater of the plant environment. As stated previously, sufficient overburden exists in the area (7 to 15 feet minimum) to adequately treat the wastes before they could enter the groundwater so that no chemical contamination of the groundwater could occur. The small amount of water discharged through the drain field would not be large enough to influence groundwater levels in the area.

10.6.3.3 Impacts on Air - There are expected to be no significant impacts on air from either of the alternative designs.

10.6.3.4 Impacts on Land - Either the subsurface drain field or sand filter sanitary waste system designs would be located just east of the 500 kv switchyard for plant A and west of the 500 kv switchyard

for plant B. The total use of land for either of these facilities is about one acre per entire site, as compared to about 0.5 acres for the proposed system. It should be noted that the land used for sanitary waste facilities would be well within the site boundary and no additional offsite land would be needed for these structures. Also the construction of the alternatives would occur within the main plant construction area so that there should be no additional impacts due to the construction on the offsite population or wildlife.

Each of the sanitary waste systems are considered aesthetically acceptable as presently located within the total facility.

These alternative facilities will not utilize large pumps, etc., which would generate noise or otherwise affect wildlife or people in the surrounding area.

Table 10.[illegible]-1

EFFLUENT RELEASE INFORMATION
FOR ALTERNATIVE SANITARY WASTE SYSTEMS

Environmental Discharges	Influent Concentration	*Alternate #1 Subsurface Drain Field	Alternate # 2 Sand Filter
		**Effluent Concentration lbs/day in each 12,000 gallons of waste effluent	
Suspended Solids	84 lbs/day	(None to Receiving Stream)	8.4
Dissolved Solids	300 ppm		29.9
BOD, 5 DAY 20°C	13.1 lbs/day		1.31
Phosphate (soluble)	1.07 lbs/day		1.07
Chlorine	-		.49

*Based on soil percolation rate of 20 minutes per inch.

**Each gallon of effluent will be mixed with 6,000 gallons of blowdown from the circulating water system before discharge to the receiving stream.

TABLE 10.6-2

BENEFIT/COST TABLE - SANITARY WASTE SYSTEMS

		Proposed	Subsurface Drainfield	Sand Filters
	Alternatives:			
Cost:	Present Worth:	288,000	256,000	378,000
	Annualized:	24,710	22,000	32,400
	Incremental Cost:	Base	32,000	90,000
Environmental Costs	**Units**			
1. Natural Surface Water Body				
1.1 Impingement or entrapment by cooling water intake structure				
1.1.1 Fish		N/A	N/A	N/A
1.2 Passage through or retention in cooling systems		N/A	N/A	N/A
1.3 Discharge area and thermal plume		No effects	No effects	No effects
1.4 Chemical effluents				
1.4.1 Water quality, chemical		Base	0	See text
1.4.2 Fish		See text	See text	See text
1.4.3 Wildlife (including birds, aquatic and amphibious mammals, and reptiles)		See text	See text	See text
1.4.4 People		See text	See text	See text

TABLE 10.6-2 (Continued)

	Environmental Costs	Units	Proposed	Subsurface Drainfield	Sand Filters
1.5	Radionuclides discharged		N/A	N/A	N/A
1.6	Consumptive use				
	1.6.1 People	Gallons/year	Base	0	0
	1.6.2 Agriculture	Gallons/year	Base	0	0
	1.6.3 Industry	Gallons/year	Base	0	0
1.7	Plant construction (including site preparation)		Base	See text	See text
1.8	Net effects	Opinion	See text	See text	See text
2.	Ground Water				
2.1	Raising/lowering of ground water levels	Feet	Base	See text	0
2.2	Chemical contamination of ground water (including salt)	Gallons/year	Base	See text	0
2.3	Radionuclide contamination		N/A	N/A	N/A
3.	Air		No effects	No effects	No effects
4.	Land				
4.1	Site selection				
	4.1.1 Land, amount	Acres	Base	0.5	0.5

TABLE 10.6-2 (Continued)

Environmental Costs	Units	Proposed	Subsurface Drainfield	Sand Filters
4. Land (Continued)				
4.2 Construction activities (including site preparation)				
4.2.1 People (amenities)	Opinion	Base	0	0
4.2.2 People (accessibility of historical sites)	Opinion	Base	0	0
4.2.3 Wildlife	Opinion	See text	See text	See text
4.2.4 Land (erosion)	Opinion	See text	See text	See text
4.3 Plant operation				
4.3.1 People (amenities)	Decibels	See text	0	0
4.3.2 People (aesthetics)	Opinion	Acceptable	Acceptable	Acceptable
4.3.3 Wildlife	Opinion	No effects	No effects	No effects

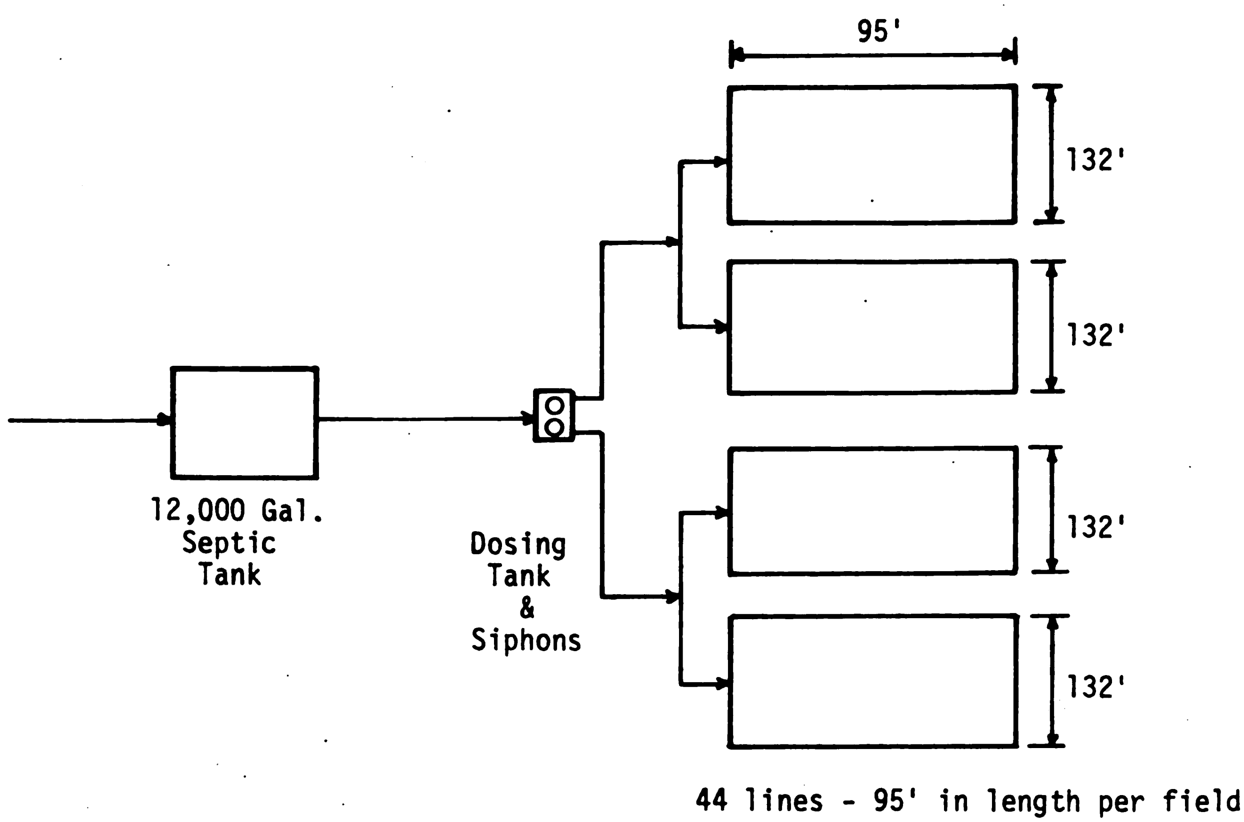

Figure 10.6-1

SUBSURFACE DRAIN FIELD
SANITARY WASTE ALTERNATIVE DESIGN

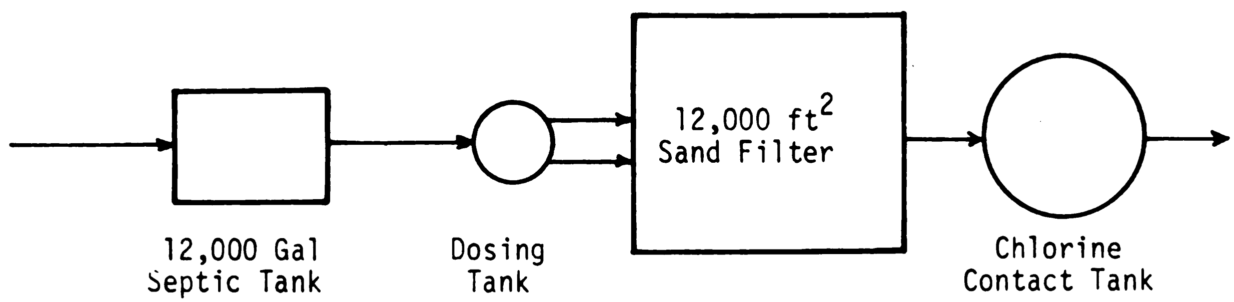

Figure 10.6-2
SAND FILTERS
SANITARY WASTE ALTERNATIVE DESIGN

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10.7 Liquid Radwaste Systems

The proposed liquid radwaste system is designed to provide treatment which reduces doses to levels which are as low as practicable. Consequently, no additional consideration is given here to alternative liquid radwaste designs.

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10.8 Gaseous Radwaste System

Effluent releases and the resultant radiation doses from the proposed gaseous radwaste systems are as low as practicable. Consequently, no additional consideration is given here to alternative gaseous radwaste designs.

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10.9 Water Intake System

The water intake system for the Hartsville plants will feature a common intake structure for both plants. This intake would not be a seismically qualified system as the essential service water system contains the required 30-day makeup supply within the system. The intake will still supply makeup for the essential service water system as well as the condenser cooling water system, the raw service water system, the water treatment plant makeup, and other plant water uses but will not be required for emergency makeup.

10.9.1 Rationale for Selection - In reviewing the proposed alternative designs, it is found that for this site there is a considerable distance from the reservoir to the plant over which the makeup water would have to be transported. There are two methods of traversing this distance which are most feasible from an engineering viewpoint. One method would be to use an open channel constructed with riprap, etc., and allowing the water to flow by gravity to the pumping station. The other method, using buried pipe and locating the pump station nearer the reservoir to pump the water to the plant, has a considerable cost disadvantage. The economics are found to be a balance of the cost of excavation against the cost of laying the pipe, running electrical conduit, etc., and pumping. At the portion of the site near the river, less excavation would be required as the land is low and the open channel would be economically favorable. Around the plant buildings, the elevation is much greater so that more excavation would be required making it more economical to lay pipe and pump the water instead of cutting the channel. By balancing the costs of excavation against the costs of pipe,

conduit, etc., and pumping cost, it is found that the optimum combination from an economic viewpoint is to locate the pumping station about 2,500 feet from the reservoir, use the open channel from that point to the reservoir, and pump the water from the station to the plant.

The consideration for the two schemes discussed above show that the major differences in impact are in the impacts on terrestrial land use. The open channel will remove about six acres of land from use as wildlife habitat, etc. This is not felt to be significant, as the land to be affected is presently agricultural land and is not regarded as highly productive wildlife habitat. Important habitat areas would be avoided. In any case, removal of this land from agricultural use would be required by the construction of the plant; therefore, there would be no additional impacts of this type on existing land use due to the intake itself.

Other impact differences between the two schemes result from the additional land which would be disturbed due to the construction of the channel. This additional construction could cause slightly higher amounts of erosion and siltation to occur. However, through the proper use of construction techniques, these effects would be minimal and will not appreciably add to the effects of overall plant construction.

The slight reduction in environmental impacts which might be gained by use of the buried pipes would not be justified considering the high cost of the alternative.

An additional alternative consideration is the method of picking up the water from the reservoir. The lowest cost design is to have an open channel at the shoreline of the reservoir, drawing the water straight in

through the channel. However, shallow shoreline area are the most productive areas in the reservoir with regard to the abundance of larval fish. These fish are not able to escape the intake flow and are subject to being entrained in the intake flow. For this reason, a reduction in environmental impact can be achieved by taking in the makeup water from deep water where larval fish are less abundant.

The preliminary analyses of the deepwater intake and the shoreline intake indicate that the additional cost of employing the deepwater intake design is justified, based on the considerable benefits which could be realized to the fish resources of the reservoir. Additional benefits which will be realized would be reductions in the amount of trash taken in and disposed of, less frequent operational requirements for washing traveling screens, and possible reductions in the entrainment of other biota from the reservoir.

10.9.2 Alternative Designs - In addition to the proposed design described in Section 3.4, the following design was considered as an alternative design and subjected to the benefit/cost analyses for evaluation with the proposed system.

This alternative would have an open channel and pumping station identical to the proposed system described in Section 3.4. However, instead of having a diked area at the end of the channel and intake pipes running out to deep water, the channel is open at the end and draws water directly into the pump station from the reservoir shoreline. Details of the design are shown in Figure 10.9-1. Flow velocities and other data would be the same as those discussed for the proposed system. Trash collection would be accomplsihed identically as the proposed method.

10.9.3 Evaluations of Impacts

10.9.3.1 Impacts on Surface Water Bodies

10.9.3.1.1 Impingement and Entrapment - Some juvenile and adult fish will be drawn into the flow of the intake water and will be impinged on the traveling screens. The amounts of fish impinged in this manner depend in part on the velocity of water taken in, and other design features and also on the abundance of fish in the area of the intake. The intake was designed to restrict the intake velocity as much as practical.

The open channel surface intake is expected to have greater impacts due to impingement than the proposed system as the channel will act as a natural cove. The resemblance to a cove and the current will result in a natural attraction for fish. Based on preliminary fish studies, expected annual losses due to impingement for the alternatives are as follows:

Alternative	Impinged Fish	Pounds of Fish Lost
Closed Channel (Proposed)	3,100	720
Open Channel	51,300	11,860
Buried Pipe	3,100	720

10.9.3.1.2 Passage Through or Retention in Cooling System - The location and design of the intake are the major determinants of the numbers of larval fish and plankton which are entrained in the makeup and killed in cooling systems. A near shore withdrawal would create a hydraulically selective intake of all suspended forms of aquatic life originating in the Dixon Creek and its embayment. By using the deepwater point of water intake, less hydraulic selection of abundant biota produced in Dixon Creek will occur.

Estimates of larval fish which are expected to be entrained are shown below. These are based on preliminary studies. No quanitative estimates are made on the amounts of plankton lost as data is not available at this time upon which an accurate estimate could be based.

Alternative	Larval Fish/Year
Closed Channel (Proposed)	16×10^6
Open Channel	268.5×10^6
Buried Pipe	16×10^6

An assumed 90 percent natural mortality rate will reduce the actual losses to one-tenth of those shown above.

10.9.3.1.3 Other Impacts on the Surface Water Bodies - Construction impacts are greater with a deep water intake because of the placement of a dike. Breaching of the shoreline following construction of the intake channel and subsequent direct dike placement will result in greater sedimentation than the alternative systems. The downstream sedimentation should be less significant because of the paucity of deep water benthos and the fact that there is steep shoreline.

Both withdrawal locations have the disadvantage of being below Dixon Creek and the disadvantage of providing suspended sediments during diking and breaching to the productive shallow channel between Dixon Island and the right bank shoreline. Slightly less sediment probably would originate at the shoreline site.

10.9.3.2 Impacts on Ground Water - There will be no significant impact on ground water from either design.

10.9.3.3 Impacts on Air - There will be no difference in impacts from either design on the air.

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10.9.3.4 Impacts on Land

10.9.3.4.1 Amount of Land - The channel intake designs would require the same amount of land. The channel would require about six acres of land to be converted to a water body for either of these alternatives.

10.9.3.4.2 Construction Impacts - The relative amounts of land disturbed would be about the same for either design so that the construction effects on terrestrial wildlife and off site populations would be equal.

The piping and channels for either design would follow the same path to the reservoir so that no differences would be expected in impacts on archaeological sites on the plant site. A discussion of these impacts is given in Section 4.1.

TABLE 10.9-1

COST/BENEFIT TABLE - WATER INTAKE SYSTEM

	Units	Proposed	Open Channel
Alternatives:		Proposed	Open Channel
Cost: Present Worth:		15,600,000	14,100,000
Annualized:			
Incremental Cost:		Base	(1,500,000)
Environmental Costs			
1. Natural Surface Water Body			
1.1 Impingement or entrapment by cooling water intake structure			
1.1.1 Fish	Number	3,100	51,300
	Pounds	720	11,860
1.2 Passage through or retention in cooling systems			
1.2.1 Phytoplankton and zooplankton		See text	See text
1.2.2 Fish	Larvae/year	0	252,500,000
1.3 Discharge area and thermal plume			
1.3.1 Water quality, excess heat		N/A	N/A
1.3.2 Water quality, oxygen availability		N/A	N/A

TABLE 10.9-1 (Continued)

Environmental Costs	Units	Proposed	Open Channel
1. Natural Surface Water Body (Contineud)			
1.3.3 Fish, nonmigratory		N/A	N/A
1.3.4 Fish migratory		N/A	N/A
1.3.5 Wildlife (including birds, aquatic and amphibious mammals, and reptiles)		N/A	N/A
1.4 Chemical effluents			
1.4.1 Water quality, chemical		N/A	N/A
1.4.2 Fish		N/A	N/A
1.4.3 Wildlife (including birds, aquatic and amphibious mammals, and reptiles)		N/A	N/A
1.4.4 People		N/A	N/A
1.5 Radionuclides discharged to water body			
1.5.1 Aquatic organisms		N/A	N/A
1.5.2 People, external		N/A	N/A
1.5.3 People, ingestion		N/A	N/A
1.6 Consumptive use			
1.6.1 People	Gallons/year	No effects	No effects
1.6.2 Agriculture	Gallons/year	No effects	No effects
1.6.3 Industry	Gallons/year	No effects	No effects

TABLE 10.9-1 (Continued)

Environmental Costs	Units	Proposed	Open Channel
1. Natural Surface Water Body (Continued)			
1.7 Plant construction (including site preparation)	Opinion	See text	See text
1.8 Other impacts		No effects	No effects
1.9 Combined or interactive effects		No effects	No effects
1.10 Net effects		See text	See text
2. Ground Water			
2.1 Raising/lowering of ground water levels	Feet	No effects	No effects
2.2 Chemical contamination of ground water (including salt)			
2.2.1 People		N/A	N/A
2.2.2 Plants		N/A	N/A
2.3 Radionuclide contamination of ground water			
2.3.1 People		N/A	N/A
2.3.2 Plants and animals		N/A	N/A
2.4 Other impacts on ground water		No effects	No effects
3. Air		N/A	N/A

TABLE 10.9-1 (Continued)

Environmental Costs	Units	Proposed	Open Channel
4. Land			
4.1 Site selection			
4.1.1 Land, amount	Acres	See text	See text
4.2 Construction activities (including site preparation)	Opinion	See text	See text
4.3 Plant operation		No effects	No effects

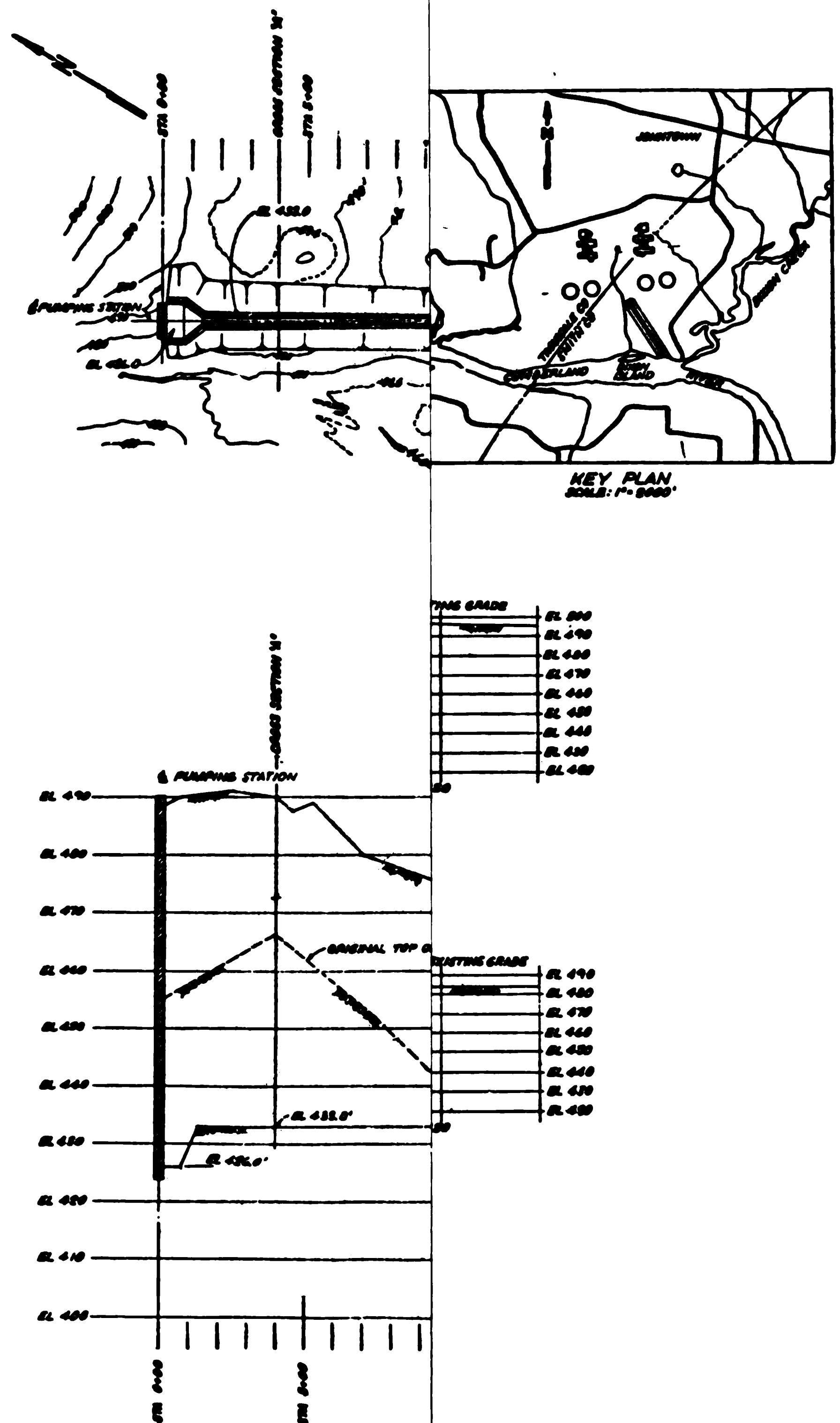

Figure 10.9-1

PLAN AND PROFILES
INTAKE CHANNEL ALTERNATIVE

10.10 Plant Discharge

10.10-1 Rationale for Selection - Water returned to the Cumberland River from the plant is mainly from two sources, blowdown from the condenser cooling water (CCW) system and blowdown from the Essential Service Water (ESW) system. Based on past experience, both of these sources will require mixing of the discharge water with the water in Old Hickory Reservoir to minimize the impacts from this discharge. The mixing of blowdown water is required primarily for two reasons. First, the mixing is required to ensure that the solids from the blowdown will be sufficiently dispersed in the diluent water to meet established standards. Secondly, although the blowdown water has been through the cooling towers, the heat content is still high enough that mixing of this water with the reservoir water is required to prevent stratification and exceeding established thermal regulations.

Several alternative discharge systems, in addition to the discharge pond-multiport diffuser system described in Section 3.4.3, were studied. The alternatives considered included a slot-jet diffuser and a design not utilizing a discharge pond.

A description of these alternatives is given in section 10.10.2.

In addition to the alternatives discussed above, consideration was given to the location of the diffuser. Economically, it was advantageous to locate the discharge structure as close to the plant as possible. This location would be at Dixon Island and pipe to the structure would cross the island.

Dixon Island and the immediate shoreline from a compact ecological setting of upland, riparian and wetland habitat so the island and its

immediate environs, along with Dixon Creek and its shoreline environs, form the most sensitive habitat at this site and constitute a significant proportion of this type habitat in the upper part of Old Hickory Reservoir. Therefore, to minimize impacts, the total area should be protected from all disturbance during the construction and operation of the discharge.

Consideration was therefore given to moving the discharge downstream to a point below the island. This location would avoid these habitat areas, thus substantially reducing the impact due to the construction. Although detailed wildlife studies have not been completed at this time, an estimate of the impact of the diffuser location on wildlife was made based on preliminary information and studies.

In addition to the wildlife benefits, the downstream location provides operational advantages. The alternative location for the diffuser system would cross Dixon Island about 800 feet upstream of the location shown on figure 3.4-3. This location means that the blowdown outlet would be within just a few hundred feet of the intake channel. During periods of low flow in the reservoir, if blowdown were discharged, it might be recycled back to the makeup water channel, reducing available cooling and increasing solids concentrations in the cooling systems.

Because of the environmental and operational benefits, the downstream location was selected for the discharge diffuser.

The review of the benefit/cost analyses shows that the multiport diffuser is preferable to the slot jet proposal because of less desirable plume effects of the slot jet design. In addition, the multiport diffuser design has some economic advantages.

The design of the pond indicates that the pond would provide some ability to hold up cooling tower blowdown during periods of low river

flow without causing a buildup of solids in the towers. It also could be used to contain accidental spills that might enter the discharge system. Radwaste discharges would be discharged downstream of the pond and would therefore not be a consideration of the pond. Although the pond would require that some land be converted from land use to aquatic area, this area would be within the plant area and would not constitute a significant impact. In addition, the discharge pond would provide additional cooling and allow some settling of particulate matter.

For the above reasons, the multiport diffuser design with the discharge pond was proposed for use at this plant.

10.10.2 Alternative Designs - In addition to the proposed design, the following alternative designs were considered.

10.10.2.1 Multiport Diffuser Without a Discharge Pond - The ESW blowdown pipelines and condenser cooling water (CCW) blowdown pipelines converge to a blowdown collecting structure constructed of reinforced concrete. The blowdown collecting structure consists of an impact stilling basin with a weir controlling overflow. Overflow is carried to the river by a grass channel. The grass channel is strictly an emergency mode of operation to be used only if the discharge piping from the blowdown structure becomes clogged. Flow from the collecting box is through an underground pipe system that is connected to a diffuser in the bottom of Old Hickory Reservoir. The diffuser would be a multiport type perpendicular to the shore. It would be identical to the proposed diffuser.

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10.10.2.2 Side-Mounted Slot Jet Diffuser - This scheme is identical to the scheme described above except that a different diffuser is used. The diffuser in this scheme is a concrete box with inside dimensions of 6 feet by 5 feet and 60 feet long. The box is located on the bottom of the reservoir with the length parallel to flow and at the edge of the deep water channel. Diffusing action will be through five slots in the top of the box that are 0.5 feet by 10 feet and located at elevation 418 msl. The peak discharge rate and velocity in the 6-foot pipe are the same as the proposed scheme. Also, the earthwork is the same. A cofferdam would be required to construct the slot diffuser in the dry.

10.10.3 Evaluations of Impacts

10.10.3.1 Impact on Surface Water Bodies - The difference in impacts from any of these alternatives on surface water bodies would be in the location, size, and the shape of the discharge plume from the diffuser.

In evaluating the diffuser discharge alternatives from the point of view of their impact upon the receiving water temperatures, only two distinct designs were treated: (1) a submerged multiport diffuser across the river channel (regardless of location and regardless of the presence of a discharge pond); (2) a submerged slotted shoreline diffuser. The analysis was based on the material presented in Appendix J entitled "The Impact of Blowdown Discharge from the Hartsville Plant on Cumberland River Water Temperatures." The following assumptions were made:

1. The blowdown temperature rise above ambient is 50° F. and the blowdown flow is 110 cfs.

2. The multiport diffuser achieves a temperature reduction to

delta-t (ΔT) = 5° F. by mixing within a zone which is 200 feet long in the downstream direction extending laterally along the length of the diffuser which is also 200 feet, and vertically to mid-depth in the river about 15 feet. These dimensions are based upon field and laboratory experience with a similar diffuser at the Browns Ferry Nuclear Plant (see Reference 2 in Appendix J). Reduction of ΔT to 3° F. and 2° F. is by surface heat loss as calculated in Appendix J for low heat loss conditions.

3. For the slotted shoreline diffuser, reduction of ΔT to 5° F. and lower is by surface heat loss only as calculated in Appendix J. The amounts of water surface area and water volumes affected for the values of ΔT reached by surface heat loss are actual reservoir surface areas and volumes between the discharge and the river mile where the indicated ΔT was reached. Particularly in the case of the water volumes which may be affected by the formation of a stratified condition downstream, these values are conservative in that they represent the maximum possible impact of the blowdown on river temperatures. The areas and volumes of water affected are as follows:

Alternative	Multiport	Slot Jet
Btu/hr discharged	1.24×10^9	1.24×10^9
Acres of water surface with $\Delta T > 5^{\circ}$ F.	0	670
Acre-ft of water with $\Delta T > 5^{\circ}$ F.	14	14,000
Acres of water surface with $\Delta T > 3^{\circ}$ F.	1,000	1,000
Acre-ft of water with $\Delta T > 3^{\circ}$ F.	20,000	20,000
Acres of water surface with $\Delta T > 2^{\circ}$ F.	1,660	1,660
Acre-ft of water with $\Delta T > 2^{\circ}$ F.	37,000	37,000

The effects of this plume on fish, wildlife, and humans are similar to those discussed in section 5.1. Some additional effects may occur for the slot jet however because of the impingement of the plume on the shore.

Treated radioactive wastes may be discharged on occasion through the discharge system. However, these wastes will be very low activity wastes, and there will be insignificant impact from any discharge alternative. The wastes would be put into the discharge below the holding pond so that there would be no possibility of impacts due to any action of the discharge pond.

There will be no impacts on the availability of water downstream for consumptive use from any of these alternatives.

The principal effects of the construction of any of the alternatives considered on the surface waters will be the disturbance of land and the resulting erosion. Listed below are the areas disturbed and the runoff which could result from the maximum predicted one hour, 5 year storm.

No.	Alternative	Construction Area	1-Hour, 5-Year Storm Estimated Runoff
	Discharge Pond and Diffuser	39.5	3.0
1.	Multiport Diffuser	9.75	0.8
2.	Slot Diffuser	9.75	0.8

Experience at other TVA construction projects where similar control techniques are used indicates runoff would contain less than 10,000 mg/l suspended solids.

The State of Tennessee does not have a stream limit for turbidity but does have an effluent guide. Since the reservoir is the only available source of dilution water available, it is not practicable or

desirable to dilute the runoff in order to meet the effluent guideline. At various times of the year, particularly during rainy seasons, the turbidity in the reservoir exceeds the limit so that runoff diluted with reservoir water would not meet the limit regardless of the dilution quantity used. Therefore, no dilution would be utilized for any alternative.

Construction of any of the alternatives will disturb some aquatic habitat. However, construction of the slot jet alternative is expected to have greater effects as it would be constructed along a longer length of the shoreline.

10.10.3.2 Impacts on Ground Water - There will be no impacts on ground water due to any of the alternative discharge schemes.

10.10.3.3 Impacts on Air - There will be no impacts on air due to any of the alternative discharge schemes.

10.10.3.4 Impacts on Land - Discharge piping extends from the plant complex southward to the Cumberland River. During construction of the systems, land will be impacted due to the earthwork requirements for laying the pipe, structure foundations, and where applicable, discharge pond construction. On completion of construction, these areas will be finished to be compatible with the landscape of the total site. However, each discharge scheme will have an emergency overflow channel to the river which could be utilized should the discharge pipe become blocked. The emergency channel will also be finished and seeded with grass so as to match the landscape as closely as possible. The amount of land occupied by the discharge system to include blowdown collection structures, emergency discharge channel, and, where applicable, the

discharge pond is as follows:

Multiport Diffuser w/Discharge Pond (Proposed)	- 40 acres
Multiple Diffuser	- 10 acres
Slot Jet Diffuser	- 10 acres

The land occupied by each of these alternatives would be within the proposed exclusion zone, thus no additional offsite land would need to be procured for the discharge alternatives.

Each of the discharge schemes are considered aesthetically acceptable. None of the schemes would have any major effect on the general overall appearance of the site.

TABLE 10.10-1

BENEFIT/COST TABLE - PLANT DISCHARGE SYSTEM

		Proposed	Slot Jet	Multiport Without Discharge Pond
Alternatives:				
Cost: Present Worth:		4,056,000	5,212,000	4,252,000
Annualized:				
Incremental Cost:		Base	1,166,000	196,000
Environmental Costs	**Units**			
1. Natural Surface Water Body				
1.1 Impingement or entrapment by cooling water intake structure				
1.1.1 Fish		N/A	N/A	N/A
1.2 Passage through or retention in cooling systems		N/A	N/A	N/A
1.3 Discharge area and thermal plume				
1.3.1 Water quality, excess heat	Acres and acre-feet	See text	See text	See text
1.3.2 Water quality, oxygen availability	Acres and acre-feet	Base	0	0
1.3.3 Fish, nonmigratory	Opinion	See text	See text	See text
1.3.4 Fish, migratory	Opinion	See text	See text	See text

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TABLE 10.10-1 (Continued)

Environmental Costs	Units	Proposed	Slot Jet	Multiport Without Discharge Pond
1. Natural Surface Water Body (Continued)				
1.3.5 Wildlife (including birds, aquatic and amphibious mammals, and reptiles)	Opinion	See text	See text	See text
1.4 Chemical effluents				
1.4.1 Water quality, chemical	Acres and acre-feet	Base	0	0
1.4.2 Fish	Opinion	See text	See text	See text
1.4.3 Wildlife (including birds, aquatic and amphibious mammals, and reptiles)	Opinion	See text	See text	See text
1.4.4 People	Opinion	See text	See text	See text
1.5 Radionuclides discharged to water body	Opinion	0	0	0
1.6 Consumptive use				
1.6.1 People	Opinion	0	0	0
1.6.2 Agriculture	Opinion	0	0	0
1.6.3 Industry	Opinion	0	0	0
1.7 Plant construction (including site preparation)	acre-feet	Base	0	2,700
1.8 Other impacts		No effects	No effects	No effects

TABLE 10.10-1 (Continued)

Environmental Costs	Units	Proposed	Slot Jet	Multiport Without Discharge Pond
1. Natural Surface Water Body (Continued)				
1.9 Combined or interactive effects		No effects	No effects	No effects
1.10 Net effects	Opinion	See text	See text	See text
2. Ground Water				
2.1 Raising/lowering of ground water levels		No effects	No effects	No effects
2.2 Chemical contamination of ground water (including salt)		No effects	No effects	No effects
2.3 Radionuclide contamination of ground water		No effects	No effects	No effects
2.4 Other impacts on ground water		No effects	No effects	No effects
3. Air				
3.1 Fogging and icing (caused by evaporation and drift)		N/A	N/A	N/A
3.2 Chemical discharge to ambient air		N/A	N/A	N/A
3.3 Radionuclides discharged to ambient air and direct radiation from radioactive materials		N/A	N/A	N/A
3.4 Other impacts on air		No effects	No effects	No effects

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TABLE 10.10-1 (Continued)

Environmental Costs	Units	Proposed	Slot Jet	Multiport Without Discharge Pond
4. Land				
4.1 Site selection				
4.1.1 Land, amount	Acres	0	0	30
4.2 Construction activities (including site preparation)				
4.2.1 People (amenities)		No effects	No effects	No effects
4.2.2 People (accessibility of historical sites)		No effects	No effects	No effects
4.2.3 People (accessibility of archaeological sites)		No effects	No effects	No effects
4.2.4 Wildlife	Opinion	See text	See text	See text
4.2.5 Land (erosion)		See text	See text	See text
4.3 Plant operation				
4.3.1 People (amenities)		No effects	No effects	No effects
4.3.2 People (aesthetics)	Opinion	Acceptable	Acceptable	Acceptable
4.3.3 Wildlife	Opinion	No effects	No effects	No effects
4.4 Salts discharged from cooling towers		N/A	N/A	N/A
4.5 Transmission route selection		N/A	N/A	N/A
4.6 Transmission facilities construction		N/A	N/A	N/A

TABLE 10.10-1 (Continued)

Environmental Costs	Units	Proposed	Slot Jet	Multiport Without Discharge Pond
4. Land (Continued)				
4.7 Transmission line operation		N/A	N/A	N/A
4.8 Other land impacts		No effects	No effects	No effects
4.9 Combined or interactive effects		No effects	No effects	No effects
4.10 Net effects		See text	See text	See text

10.11 Transmission Facilities

In the initial route selection process, numerous possible alternate locations were investigated before the preferred corridors were selected. **Figure 3.9-1 has been marked (dotted line) to identify alternate route** corridors which were investigated for the line connections to the Hartsville Nuclear Plant. The text which follows describes the alternate route selections depicted in the **figure and sets forth the major land** use differences involved between the proposed and alternate routes. The other environmental impacts of line routing are discussed in section 3.9 of the text with regard to the proposed route. Since variations in the location of the line do not significantly vary the kinds of impacts that would be expected, the discussion found in sections 4.3 and 5.6 are equally applicable here.

10.11.1 Corridor 1a -

Section A-E (14 miles) - Corridor 1a exits the Hartsville plant northward across open pasture land, crossing Tennessee Highway 25 northwest of Dixon Springs before swinging northwestward toward point E. The corridor traverses wooded hilly terrain and crosses Tennessee Highway 10 east of Hartsville. Continuing northwestward, the corridor passes north of the existing commercial and residential developments of Hartsville. The corridor then crosses Tennessee Highway 141 northwest of Hartsville in a low area alongside Little Goose Creek. Proceeding northwestward, Corridor 1a crosses open pasture land and wooded ridges before intersecting with the Gallatin-Lafayette 161-kV line at point E. At this point the 161-kV underbuilt lines would **tap** the existing Gallatin-Lafayette line and the two 500-kV lines would continue.

Section E-C (10 miles) - The corridor continues through wooded hilly terrain crossing U.S. Highway 231 north of Paynes Store where the highway cuts between two wooded hills. Proceeding due west, the corridor traverses open fields and pasture land and intersects with the preferred route at point C.

The existence of rail connections north of Hartsville greatly enhances its potential for combined industrial and commercial development in this area of town. Corridor 1a would be approximately 11 percent longer than the preferred route and would require clearing of about 30 percent more acres of woodland. Corridor 1 was therefore selected as the preferred route.

10.11.2 Corridor 2a -

Section A-K (6.5 miles) - Corridor 2a exits the Hartsville Nuclear Plant eastward for a span or two before turning southward and crossing the Wilburn Creek embayment of Old Hickory Lake. The corridor continues southward along the eastern side of Beasleys Bend Peninsula and crosses the Cumberland River at approximately river mile 294. After crossing the river, Corridor 2a continues approximately .25 miles to the intersection with the Gallatin-Cordell Hull 161-kV line at point K. At this point, the 161-kV line from Hartsville would tap the Gallatin-Cordell Hull 161-kV Transmission Line.

Section K-G (58 miles) - The corridor continues southward, crossing mostly woods before crossing U.S. Highway 70N at a low point in the road next to Plunkett Creek and 2.0 miles southeast of the community of Rome. Continuing southward, the corridor traverses mostly wooded hills and ridges before crossing Tennessee Highway 141 southeast of Grant and north

of Interstate 40. Corridor 2a continues south, crossing open pasture land before crossing Interstate 40 as the Interstate curves slightly southward. The corridor approaches the Interstate from the north coming up a slight grade which will reduce visibility of the corridor. Trees south of the interstate will serve as a shield for the corridor. Turning slightly southwest, the corridor continues across wooded rolling hills and open patches of farmland. It crosses Tennessee Highway 26 in an open area where the highway dips and parallels a small stream. Corridor 2a continues southward crossing rolling wooded hills and open farmland interspersed with areas of rugged wooded ridges to point G. A number of U.S. and state highways are crossed by this alternate corridor location with U.S. Highway 70S and U.S. Highway 41 being the more highly developed, both residentially and commercially.

The length of Corridors 2 and 2a are approximately the same; however, the land in the valley east of Murfreesboro has greater developmental potential than the more rugged land traversed by Corridor 2. The rapid intensification of land use presently exhibited adjacent to U.S. Highways 70S and 41, in the vicinity of Murfreesboro, indicates that conflicts with future developments would be highly probable. Corridor 2 was therefore selected as the corridor having the least environmental impact.

<u>10.11.3 Corridor 3a</u> -

<u>Section A-O (10.0 miles)</u> - Corridor 3a exits the nuclear plant westward for a span or two before turning southwestward and crossing the Cumberland River at river mile 283. The corridor traverses open fields and small woodland areas and crosses Tennessee Highway 141 approximately 9.0 miles northeast of Lebanon before intersecting with the Gallatin-Cordell Hull 161-kV line at point O.

Section O-P (14.0 miles) - At point O, the underbuilt 161-kV circuit would tap the Gallatin-Cordell Hull 161-kV line, and the 500-kV circuits would continue southwestward crossing U.S. Highway 231 at a low point where Spring Creek crosses the highway. Continuing southwestward, the corridor crosses mostly open farmland before crossing U.S. Highway 70 west of Lebanon. Before the construction of Interstate 40, U.S. Highway 70 was the primary transportation link between Lebanon and Nashville. With the construction of the interstate, its importance has diminished somewhat, but the potential for future residential development still exists. Continuing southward, the corridor traverses open farmland west of Lebanon and crosses Interstate 40 at a point where the interstate cuts between two ridges. Corridor 3a would then intersect the Wilson-Bull Run 500-kV line at point P.

Section P-R (24.0 miles) - At point P, two of the 500-kV lines occupying this corridor would connect with the Wilson-Bull Run 500-kV line. The remaining 500-kV line from Hartsville would continue toward the Maury 500-kV Substation west of the Cedars of Lebanon State Park traversing open flat land which has valuable residential development potential. The next major obstacle which had to be considered was the J. Percy Priest Reservoir. Places to cross the reservoir with the transmission line corridor are quite limited because the shoreline is rapidly being developed into water-based recreation areas and exclusive residential subdivisions. A point for crossing the reservoir would be selected which avoids these existing developments. Continuing across open land, the corridor would cross U.S. Highway 41-70S between Smyrna and Murfreesboro. These crossings would be in areas where existing trees on each side of the highway will visually shield the transmission line

from the highway. Corridor 3a next crosses Interstate 24 in a flat open area adjacent to Overall Creek before continuing southward crossing Tennessee Highway 96 east of Murfreesboro and intersects with the preferred route corridor at point R. Corridor 3a traverses several areas that are presently under active development or which have good residential and water-based recreation potential. Notably, these are the areas west of Lebanon along U.S. Highway 70 and the land adjacent to the J. Percy Priest Reservoir. Due to the closer proximity to the Nashville metropolitan area, this corridor would also traverse more congested areas. For these reasons, Corridor 3a was rejected in favor of Corridor 3.

Table 10.11-1

BASIC TABULATION TO BE USED IN COMPARING ALTERNATIVE TRANSMISSION ROUTES

Environmental Costs	Units	Proposed Corridors	Alternate Corridors
1. Land use (Rank alternative routes in terms of conflict with present and planned land use)		Restrictions on right of way use Same	Same
2. Property values (Rank alternative routes in terms of total loss in property values)		No expected change in value outside of right of way	
3. Multiple use (Rank alternative routes in terms of envisioned multiple use of land pre-empted by rights of way)		Same	Same
4. Length of new rights of way required	Miles	Base	0
5. Number and length of new access and service roads required		Base	0
6. Number of major road crossings in vicinity of intersection cr interchanges		None	None
7. Number of major waterway and railroad crossings		Base Base	(2 Waterway) 0 Rail
8. Number of crest, ridge, or other high point crossings	See text	Base	11
9. Number of "long views" or transmission lines perpendicular to highways and waterways		28 Highway 4 Waterway	31 Highway (2 Waterway)

Table 10.11-1 (Continued)

BASIC TABULATION TO BE USED IN COMPARING ALTERNATIVE TRANSMISSION ROUTES

Environmental Costs	Units	Proposed Corridors	Alternate Corridors
10. Length of above transmission line or through the following visually sensitive areas			
10.1 Natural water body shoreline		See text	See text
10.2 Marshland		None	None
10.3 Wildlife refuges		None	None
10.4 Parks		None	None
10.5 National and state monuments		None	None
10.6 Scenic areas		None	None
10.7 Recreation areas		None	None
10.8 Historic areas		None	None
10.9 Residential areas		None	None
10.10 National forests and/or heavily timbered areas		None	None
10.11 Shelter belts		None	None
10.12 Steep slopes		None	None

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Table 10.11-1 (Continued)

BASIC TABULATION TO BE USED IN COMPARING ALTERNATIVE TRANSMISSION ROUTES

Environmental Costs	Units	Proposed Corridors	Alternate Corridors
10.13 Wilderness areas		None	None
10.14 to 10.20 (Other sensitive or critical areas, specify)		None	None
10.21 Total length through sensitive areas (sum 10.1-10.20)		See text	See text
10.22 Total net length through sensitive areas (sum 10.1-10.20 eliminate duplication)		See text	See text

11.0 General Benefit-Cost

10.12 Access Railroad Route

An access railroad will be required for the Hartsville plant to allow equipment and material which are too large or heavy to be transported by truck to be brought to the site. In addition, use of the railroad for transporting other goods will reduce traffic and congestion on the roads of the area by reducing the number of trucks servicing the site. The closest available rail-spur is located in Hartsville approximately 5 miles from the site. Alternative routes were considered in order to minimize the environmental effects of the railroad.

10.12.1 Rationale for Selection - Three possible routes were studied as access routes to the Hartsville site. These routes are shown on Figure 10.12-1 and are designated as alternates A, B, and C.

Alternatives B, and C have different types of adverse land use and socioeconomic impacts but, on balance, they seem to be roughly equivalent. Alternative C has the better positive impact in that it would provide rail access directly to more potential waterfront industrial land. However, alternative B is significantly shorter and a spur could still serve the additional waterfront site.

The terrain on alternates A and C is much rougher than alternate B, requiring larger cut and fill sections. In areas where cuts would be required on alternates A and C, field inspections revealed rock outcrops. Construction of alternates A and C would require more land for construction, would be longer, require the construction of more bridges and grade separations, and cross more existing roads. Alternate B is therefore proposed over alternates A and C.

10.12.2 Alternative Routes - Alternate A begins 2+ miles northwest of Hartsville and generally lies north and east of the city of Hartsville and the proposed route. Alternate C begins 0.3+ miles west of the city of Hartsville and circles west and south of the city of Hartsville and ties into the proposed route about 3 miles west of the plant site.

The proposed access railroad route is the most direct route from the end of a spur track in Hartsville to the plant site, a distance of approximately 5.6 miles. The proposed route generally follows the flood plains of Little Goose Creek, Big Goose Creek, and the Cumberland River (Old Hickory Lake). By following the flood plain, the grades are not expected to exceed 2.5 percent. The terrain is generally rolling and does not require large cut or fill sections, thereby requiring a minimum amount of land for construction. The proposed route only crosses one major stream (Big Goose Creek) that would require the construction of a bridge.

The proposed route will cross two city streets and one county road which terminates approximately one mile after its intersection with the railroad. Because of the low speeds on the city streets and the low volume of traffic on the county road, these crossings will be made at grade. The path of the proposed route through Hartsville is shown in Figure 10.12-2.

10.12.3 Impacts of the Alternatives - Alternative A is the longest route (7.7 miles) and would pass through primarily open land with some scattered forest cover. It could have a small beneficial effect on future land use since a small potential industrial area (115 acres) is along the route. However, no other intense development is projected along the alignment.

The proposed access railroad route (alternative B) is the shortest (5.6 miles) and would start in downtown Hartsville at the end of an existing spur and would pass across the back of several large residential lots which abut an area presently used for industrial purposes. It would then cross the edge of an open field used for recreation purposes and then pass near additional residences before entering the open, undeveloped area southeast of Hartsville. The land use along the remainder of the alignment is characteristically undeveloped.

The impact of the railroad on the residences near the center of town is small because of the existing industrial use influencing the character of the area. The impact on the playfield appears to be limited to a reduction in the parking area. However, only through final design and field survey can the impact on the ballfield be accurately assessed.

Future land use patterns may be altered to some extent along the railroad due to the enhancement of several tracts of land for industrial use. Three of these areas are south and southeast of Hartsville with a total area of about 670 acres. The Hartsville Future Land Use Plan shows a portion of one site as future industrial, but most of the sites are located in areas designated for future residential development. However, it appears that with the topography and road pattern these industrial areas could be integrated into the land use plan with a minimum of conflict. Another apparent conflict with the future land use plan is the ballfield tract. On the future land use plan, it is shown as recreation, but on the Hartsville Public Facilities Plan, it is shown as a civic center. The recreation use could be continued with the railroad, but it would probably preclude the civic center. However, the recently prepared 20-year Public Improvement Program report does not

include the civic center as a capital expenditure and discussions with Tennessee State Planning Office staff indicate that it is unlikely to be realized. Therefore, line B could probably be made compatible with the future land use plan.

Alignment C is 7.1 miles long and would skirt most of the developed portions to the north and west of Hartsville. The exception is residential development in the vicinity of the crossing of State Highway 141 to the south. This is a more significant land use impact than alignment B because the development is strictly residential and relatively recent. The railroad would change the character of the area and possibly preclude a continuation of the type of residential development occurring there. Alignment C would provide rail access to 1,070 acres of potential industrial land.

Alternative A would have the least adverse socioeconomic impact because it would probably not require any relocations and does not pass near or through developed areas. However, this alternative would have the least positive impact on potential development of the community since only a small tract of land is enhanced for potential industrial use.

Alternative B would pass directly across at least four residential lots and pass within about 100 feet of eight dwellings. Two dwellings would have to be relocated. The size and character of a playfield might be adversely affected.

Detailed information on rail traffic during construction is not available. During operation, plant-related shipments are expected to occur very infrequently, on the order of once a month or less. If this is the case, then the rail traffic due to the project would not likely create a significant impact. The opportunity to attract rail-oriented

industry to Hartsville is a beneficial socioeconomic impact of Alternative B and with an additional short spur another area with potential for water-oriented industrial use could be developed.

Alternative C appears to require the relocation of at least two residences and would impact approximately the same number as Alternative B. Alternative C offers generally the same opportunity for industrial development as B, but no additional spur would be required to develop the additional water-oriented site.

The various items for comparing the three routes are listed in the following table.

	Alternate A	Alternate B	Alternate C
Length of track	7.7 miles	5.6 miles	7.1 miles
Road crossings	5	3	4
Road crossings requiring bridges	2	0	1
Major stream crossings requiring bridges	1	1	2
Relocations	0	2	2
Enhanced industrial land	115 acres	670 acres	1,170 acres

Figure 10.12-1

ACCESS RAILROAD ALTERNATIVE ROUTES

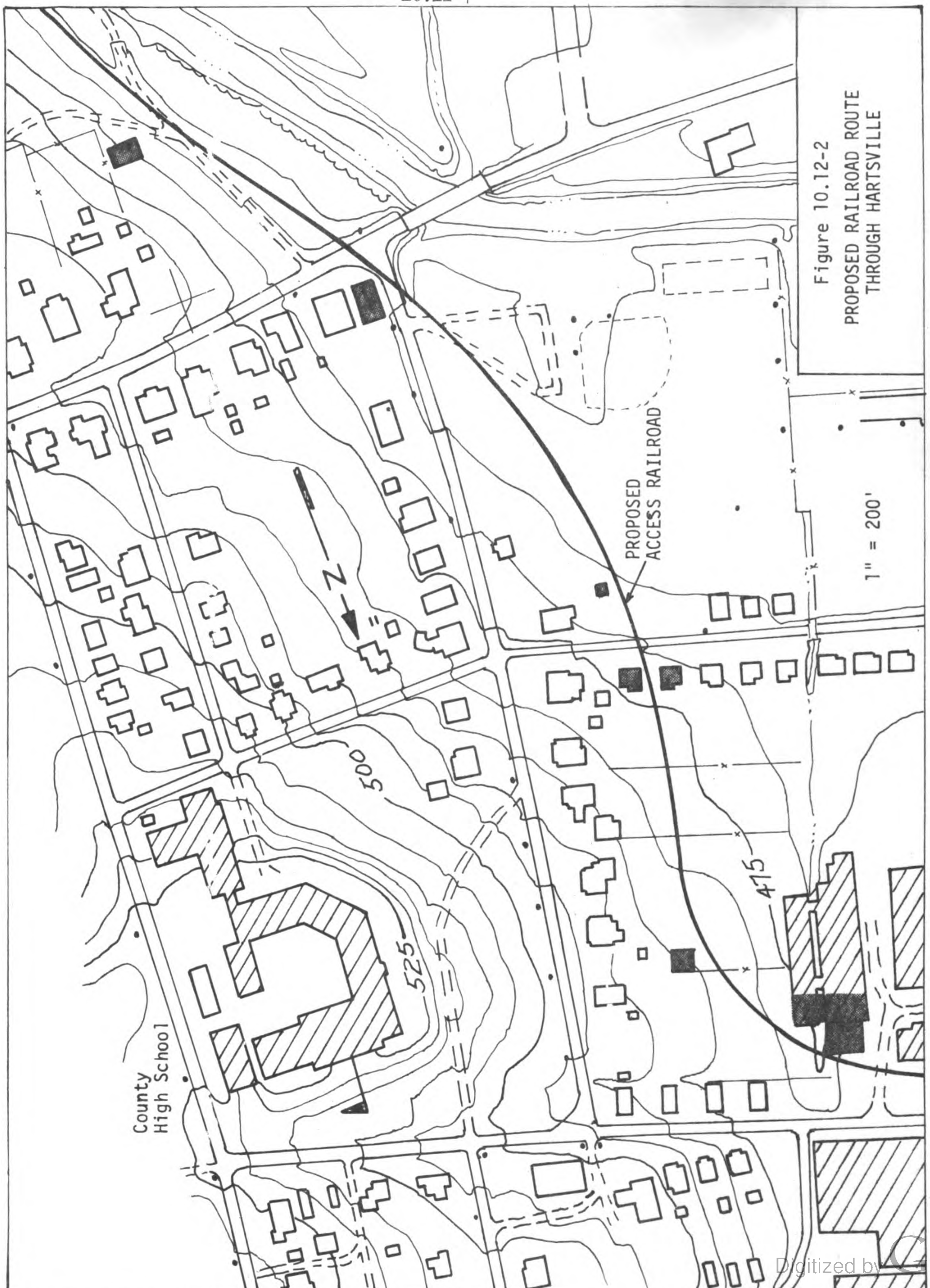

Figure 10.12-2
PROPOSED RAILROAD ROUTE
THROUGH HARTSVILLE

11.0 Summary Benefit-Cost Analysis

11.1

11.1 Summary Benefit-Cost Analysis

This section summarizes the benefits and costs associated with the proposed Hartsville Nuclear Plant.

11.1.1 Benefits - The benefits that will be derived from this plant are discussed qualitatively in Section 8.0 and quantitatively in Section 8.1

Included in these benefits are an ample supply of electricity to meet the region's needs and allow continued improvement of the quality of life in the region, the value of the electricity in revenues, increased payments in lieu of taxes to state and local governments, increase in regional gross product, recreational benefits, an improvement in air quality resulting from using less fossil-fuel, increased employment and employment potential, and education benefits derived from visits to the plant. These quantifiable benefits are tabulated in tables 8.1-1 and 8.1-2.

11.1.2 Costs - The costs associated with the construction and operation of the plant will fall into three categories: economic, social, and environmental.

11.1.2.1 Economic Costs - The economic cost for constructing and operating the plant over a 35-year life include capital costs of land acquisition and improvement, capital costs of facility construction, capital costs of transmission and distribution facilities, fuel costs, operating and maintenance costs, plant decommissioning, license fees, and payments in lieu of taxes. These costs are discussed in section 8.2 and are tabulated in table 8.2-1.

11.1.2.2 Social Costs - Social costs associated with the construction and operation of a nuclear plant are complex and subject to modification by many factors. These costs are not easily quantified; and when quantifiable, it can seldom be done in monetary terms. Those social costs identified to date are discussed in Sections 4.2 and 8.2. Additional costs may be identified as studies progress. Also, programs for mitigating the social costs will be developed after additional study and consultation with local officials.

11.1.2.3 Environmental Costs - The environmental costs associated with the proposed plant are discussed in detail in Sections 4.1 and 5.1 through 5.9. A summary of these costs is given below. A discussion and tabulation of costs associated with subsystem alternatives are contained in Sections 10.1 through 10.12.

Natural Surface Water Body - Impingement of adult fish due to the water intake is estimated to be 3,100 fish (720 pounds) per year. Mortality is assumed to be 100 percent.

All aquatic organisms that pass through the intake screens are assumed to be destroyed. Because of the deep-water location of the intake structure, an insignificant amount of phytoplankton and zooplankton will be entrained. Larval fish entrainment is estimated to be 16×10^6 larval fish per year.

The discharge is expected to release approximately 1.2×10^9 Btu/hr of heat to the reservoir. A mixing zone approximately 200 feet wide, 15 feet deep, and 150 feet long will be created by the discharge. The area and volume of water with temperature rises greater than 5°F., 3°F., and 2°F. is tabulated in table 11.1-1. Dissolved oxygen in the discharge water is expected to be greater than 5 mg/l due to aeration by the cooling towers. Fish

(nonmigratory) are expected to avoid the turbulence at the mixing zone and, because of the small change in temperature outside the mixing zone, no adverse effect is expected. Since the discharge diffuser and mixing zone do not span the entire river, there will be no barrier to fish migration and no other adverse effects on migratory fish are expected as a result of the discharge from the plant. The discharge is not expected to adversely affect any other wildlife.

Chemical effluents discharged from the plant will not appreciably impair the water quality of the Cumberland River. No additional dilution of the discharge is required after initial jet mixing in the reservoir to meet water quality standards. Therefore, no adverse effect is expected on aquatic organisms, wildlife, or people.

Doses to aquatic organisms as a result of radionuclides discharged from the plant are tabulated in table 5.2-4 in Section 5.2. Internal and external doses to people as a result of radionuclides discharged from the plant are tabulated in table 5.3-7.

Consumptive use of water at the plant will not diminish the supply of water needed by people, agriculture, or industry.

Erosion during plant construction will average about 1,500 tons per year. A portion of the silt is expected to settle in the yard drainage pond or holding ponds and no significant impact is expected in Old Hickory Reservoir. Chemicals used for cleaning during construction will be routed to holding ponds and neutralized before being released to the reservoir. No significant impairment of water quality is expected due to chemical cleaning during construction.

Net effects on Old Hickory Reservoir are expected to be inconsequential.

<u>Ground Water</u> - Ground water may be temporarily raised or lowered in the immediate vicinity of construction. However, this effect should not extend offsite nor last after construction is completed. No other

significant effects on ground water are expected.

Air - Fogging and icing caused by the evaporation and drift from the natural draft cooling towers are not expected to affect ground, water, or air transportation. River fog due to plant discharge is estimated to affect river traffic about 497 hours per year. Vegetation is not expected to be significantly affected by fogging and icing.

Resulting average annual ambient pollutant levels due to gaseous emissions from the plant's auxiliary boilers and diesel generators have been estimated assuming combustion of 1.59×10^7 gallons per year of fuel oil with 0.5 percent sulfur content. Resulting annual average ambient levels as percents of the ambient air quality standards, and tons per year of emissions assuming a comsumption rate of 1,815 gallons per hour are given in Section 3.7. No odor originating from normal operation of the plant should be perceptible at any point offsite.

Doses due to radionuclides discharged to ambient air and direct radiation from radioactive materials are tabulated in table 5.3-7 for people and table 5.2-5 for plants and animals.

There have been no significant impacts on air identified other than those discussed above.

Land - Approximately 1,940 acres of land will be contained within the site boundary.

Construction activities at the site will be controlled such that there will be no significant disturbances offsite due to noise and dust.

Accessibility of any historical site will not be affected by construction activity except possibly by traffic congestion due to increased traffic during construction.

Archaeological sites that are significant will be investigated prior to construction in the immediate area of the sites.

If there are any sites of significance in the exclusion area that have not been investigated prior to plant operation, access to them will be restricted.

Land erosion during construction will average approximately 1,500 tons per year as approximately 700 to 800 acres of land are disturbed for facilities construction.

There should be no significant increase in noise levels offsite due to plant operation.

The visual effects of the plant are depicted in composite photographs contained in Section 3.1. Although the plant and cooling towers are massive structures, location, design, and screening will reduce the visual impact offsite.

Operation of the plant should increase both diversity and abundance of wildlife since the site will be restricted and, except for the immediate vicinity of the structures, most of the land will be allowed to revert to a natural state.

Salts discharged by drift from the cooling towers are expected to fall primarily within 2,000 feet of the cooling towers. This area is completely within the site boundary. Since ground water in the site area moves toward the reservoir, no effects on ground water supplies of people in the area will occur. Plants and animals within the area of drift deposition may be affected by changes in moisture or chemical regimes; however, the changes would probably be subtle and extremely difficult to disassociate from other cause and effect phenomena. Property resources offsite will not be significantly affected by deposition of salts.

New transmission line rights of way needed for the Hartsville Nuclear Plant will amount to 194 miles and a total of 5,400 acres. Land use and aesthetics are discussed in Sections 4.3 and 10.11 and tabulated in table 10.11-1.

Transmission facilities construction will require an estimated 116 miles of access roads.

Net effects on land will involve the use of approximately 7,415 acres of land in which present use may be changed and for which future use will be restricted.

11.1.3 Environmental Consideration for Uranium Fuel Cycle - Notice was published in the Federal Register of April 22, 1974, by the AEC that consideration of the environmental effects of the uranium fuel cycle would be required pursuant to 10 C.F.R. Part 50, Appendix D, in benefit-cost analyses reported in an applicant's environmental report. Table S-3 of that notice is included as Table 11.1-2 in accordance with this requirement.

Detailed discussion of the effects of transportation associated with operation at this plant are contained elsewhere in this statement.

Consideration in the benefit-cost analysis of the environmental effects associated with the uranium fuel cycle due to the Hartsville project does not alter the conclusion that the benefits outweigh the costs for the project.

Table 11.1-1

COST DESCRIPTION OF PROPOSED FACILITY AND TRANSMISSION HOOK-UP

(All Monetized Costs Expressed in Terms of Their Present and Annualized Values)

Generating Cost	Present Worth	- $3,091,043,000
	Annualized	- $ 256,211,000
Transmission and Hook-up Cost	Present Worth	- $ 114,930,000
	Annualized	- 9,861,000

Environmental Costs	Units	Magnitude
1. NATURAL SURFACE WATER BODY		
1.1 Impingement or entrapment by cooling water intake structure		
1.1.1 Fish	No. of fish	3,100
	Pounds of fish per year	720
1.2 Passage through or retention in cooling systems		
1.2.1 Phytoplankton and zooplankton		See text
1.2.2 Fish	Larval fish per year	16×10^6
1.3 Discharge area and thermal plume		
1.3.1 Water quality, excess heat	Btu/hr discharged	1.24×10^9
	Acres of water surface with $\Delta T > 5°$ F.	0
	Acre-feet of water with $\Delta T > 5°$ F.	14
	Acres of water surface with $\Delta T > 3°$ F.	1,000
	Acre-feet of water with $\Delta T > 3°$ F.	20,000

Table 11.1-1
(continued)

Environmental Costs (see Table 3)	Units	Magnitude
	Acres of water surface with $\Delta T > 2^\circ$ F.	1,660
	Acre-feet of water with $\Delta T > 2^\circ$ F.	37,000
1.3.2 Water quality, oxygen availability	Volume of water with concentration less than 5 mg/1	0
1.3.3 Fish, nonmigratory	Number of fish	See text
1.3.4 Fish, migratory	Number of fish	See text
1.3.5 Wildlife (including birds, aquatic and amphibious mammals, and reptiles)	Number of organisms	See text
1.4 Chemical effluents		See text
1.5 Radionuclides discharged to water body		
1.5.1 Aquatic organisms		See Table 5.2-4
1.5.2 People, external		See Table 5.3-7
1.5.3 People, ingestion		See Table 5.3-7
1.6 Consumptive use		
1.6.1 People	Gallons per year	0
1.6.2 Agriculture	Acre-feet per year	0
1.6.3 Industry	Gallons per year	0
1.7 Plant construction (including site preparation)		
1.7.1 Water quality, physical		See text
1.7.2 Water quality, chemical		See text
1.7.3 Aquatic		See page 11.1-3
1.8 Other impacts		None expected
1.9 Combined or interactive effects		None identified
1.10 Net effect	Qualified opinion	See text

Table 11.1-1
(continued)

Environmental Costs	Units	Magnitude
2. GROUND WATER		See Text
3. AIR		
3.1 Fogging and icing (caused by evaporation and drift)		
3.1.1 Ground transportation	Hrs. per year	0
3.1.2 Air transportation	Hrs. per year	0
3.1.3 Water transportation	Hrs. per year	497
3.1.4 Plants	Qualified opinion	See text
3.2 Chemical discharge to ambient air		See text
3.3 Radionuclides discharged to ambient air and direct radiation from radioactive materials		
3.3.1 People, external		See Table 5.3-7
3.3.2 People, ingestion		See Table 5.3-7
3.3.3 Plants and animals		See Table 5.2-5
3.4 Other impacts on air		None identified
4. LAND		
4.1 Site selection		
4.1.1 Land, amount	Acres	1940
4.2 Construction activities (including site preparation)		
4.2.1 People (amenities)		See text
4.2.2 People (accessibility of historical sites)		See text
4.2.3 People (accessibility of archeological sites)		See text
4.2.4 Wildlife		See text
4.2.5 Land (erosion, affected area)	Tons per year Acres	1,500 700 to 800

12.0 Environmental Approvals &

Table 11.1-1
(continued)

Environmental Costs	Units	Magnitude
4.3 Plant operation		
4.3.1 People (amenities)		None
4.3.2 People (aesthetics)		See text
4.3.3 Wildlife		See text
4.3.4 Land, flood control		N/A
4.4 Salts discharged from cooling towers		
4.4.1 People	No. of people	None
4.4.2 Plants and animals	Area	See Section 5.4
4.4.3 Property resources		No effect
4.5 Transmission route selection		
4.5.1 Land, amount	Miles	194
4.5.2 Land use and land value	Acres	5,400
4.5.3 People (aesthetics)		See table 10.11-1
4.6 Transmission facilities construction		
4.6.1 Land adjacent to right-of-way	Miles	116
4.6.2 Land, erosion	Tons/Acre/Year	0.5
4.6.3 Wildlife		See Section 4.3.2
4.6.4 Flora		See Section 4.3.2
4.7 Transmission line operation		
4.7.1 Land use		See Section 5.6
4.7.2 Wildlife		See Section 5.6
4.8 Other land impacts		
4.8.1 Access railroad	Acres	75
4.9 Combined or interactive effects		None
4.10 Net effects		See text

Table 11.1-2

SUMMARY OF ENVIRONMENTAL
CONSIDERATIONS FOR URANIUM FUEL CYCLE
(Normalized to Model 1,000 MWe LWR Annual Fuel Requirement)

Natural Resource Use	Total	Maximum Effect per Annual Fuel Requirement of Model 1,000 MWe LWR
Land (acres):		
Temporarily committed	63.0000	
Undisturbed area	45.0000	
Disturbed area	18.0000	Equivalent to 90 MWe coal-fired power plant
Permanently committed	4.6000	
Overburden moved (millions of MT)	2.7000	Equivalent to 90 MWe coal-fired power plant
Water (millions of gallons):		
Discharged to air	156.0000	≈2 percent model 1,000 MWe LWR with cooling tower
Discharged to water bodies	11,040.0000	
Discharged to ground	123.0000	
Total	11,319.0000	<4 percent of model 1,000 MWe LWR with once-through cooling
Fossil fuel:		
Electrical energy (thousands of MW hours)	317.0000	<5 percent of model 1,000 MWe LWR output
Equivalent coal (thousands of MT)	115.0000	Equivalent to the consumption of a 45 MWe coal-fired power plant
Natural gas (millions of scf)	92.0000	<0.2 percent of model 1,000 MWe energy output
Effluents--chemical (MT):		
Gases (including entrainment):[1]		
SO_x	4,400.0000	
NO_x[2]	1,177.0000	Equivalent to emissions from 45 MWe coal-fired plant for a year
Hydrocarbons	13.5000	
CO	28.7000	
Particulates	1,156.0000	

Table 11.1-2
(continued)

Natural Resource Use	Total	Maximum Effect per Annual Fuel Requirement of Model 1,000 MWe LWR
Other gases:		
F^-	0.7200	Principally from UF_6 production enrichment and reprocessing. Concentration within range of state standards--below level that has effects on human health.
Liquids:		
SO_4^-	10.3000	From enrichment, fuel fabrication, and reprocessing steps.
NO_3^-	26.7000	Components that constitute a potential for adverse environmental effect are present in dilute concentrations and receive additional dilution by receiving bodies of water to levels below permissible standards. The constituents that require dilution and the flow of dilution water are: NH_3 - 600 ft^3/s; NO_3 - 20 ft^3/s; Fluoride - 70 ft^3/s
Fluoride	12.9000	
Ca++	5.4000	
Cl^-	8.6000	
Na^+	16.9000	
NH_3	11.5000	
Fe	0.4000	
Tailings solutions (thousands of MT)	240.0000	From mills only--no significant effluents to environment
Solids	91,000.0000	Principally from mills--no significant effluents to environment
Effluents--Radiological (curies)		
Gases (including entrainment):		
Rn-222	75.0000	Principally from mills--maximum annual dose rate <4 percent of average natural background within 5 mi of mill. Results in 0.06 man/rem per annual fuel requirement.
Ra-226	0.0200	
Th-230	0.0200	
Uranium	0.0320	

Table 11.1-2
(continued)

Natural Resource Use	Total	Maximum Effect per Annual Fuel Requirement of Model 1,000 MWe LWR
Effluents--Radiological (curies)		
Gases (including entrainment): (Continued)		
Tritium (thousand)	16.7000	Principally from fuel reprocessing plants--Whole body dose is 6.0 man/rem per annual fuel requirements for population within 50 mi radius. This is <0.007 percent of average natural background dose to this population. Release from Federal Waste Repository of 0.005 Ci/yr has been included in fission products and transuranics total.
Kr-85 (thousands)	350.0000	
I-129	0.0024	
I-131	0.0240	
Fission products and transuranics	1.0100	
Liquids:		
Uranium and daughters	2.1000	Principally from milling--included in tailings liquor and returned to ground--no effluents; therefore, no effect on environment.
Ra-226	0.0034	From UF_6 production--concentration 5 percent of 10 CFR 20 for total processing of 27.5 model LWR annual fuel requirements.
Th-230	0.0015	
Th-234	0.0100	From fuel fabrication plants--concentration 10% of 10 CFR 20 for total processing 26 annual fuel requirements for model LWR.
Ru-106[3]	0.1500	From reprocessing plants--maximum concentration 4 percent of 10 CFR 20 for total reprocessing of 26 annual fuel requirements for model LWR.
Tritium (thousands)	2.5000	
Solids (buried):		
Other than high level	601.0000	All except 1 Ci comes from mills--included in tailings returned to ground--no significant effluent to the environment, 1 Ci from conversion and fuel fabrication is buried.
Thermal content (billions of Btu's)	3,360.0000	<7 percent of model 1,000 MWe LWR.

Table 11.1-2
(continued)

Natural Resource Use	Total	Maximum Effect per Annual Fuel Requirement of Model 1,000 MWe LWR
Transportation (man-rem):		
Exposure of workers and general public	0.3340	

[1]Estimated effluents based upon combustion of equivalent coal for power generation.
[2]1.2 percent from natural gas use and process.
[3]Cs-137 (0.075 Ci/AFR) and Sr-90 (0.004 Ci/AFR) are also emitted.

12.0 Environmental Approvals & Consultations

12.0 Environmental Approvals and Consultations

In addition to its own standards, TVA as a Federal agency is subject to comprehensive and broad-scale environmental procedures and Federal and state consultation and coordination requirements of the National Environmental Policy Act of 1969, 42 U.S.C. §§ 4331 et seq (1970) (as implemented by Executive Order 11514 (3 C.F.R. 526 [1972]). In addition, TVA is subject to Executive Order 11507 (3 C.F.R. 519 [1972]), and Office of Management and Budget Circulars A-78 and A-81, relating to the prevention, control, and abatement of air and water pollution in Federal facilities, as well as certain provisions of the Clean Air Act, as amended, 42 U.S.C.A. § 1857 (1971), and the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500), which relate to the applicability of various Federal, state, interstate, or local air and water quality standards. In addition, TVA is subject to the requirements of Office of Management and Budget Circular A-95 which ensure that major generating and transmission projects are coordinated from the point of view of community impact and land use planning with state and local agencies.

TVA has been consulting with state and regional organizations since October 1972 about the possibility of a nuclear plant at the Hartsville site and its implications on the development of the area.

On October 6, 1972, TVA met with officials of the State of Tennessee in Nashville to discuss sites in the middle Tennessee area which might be the location for a nuclear plant. The need was established for early input from the State on four sites. On November 1, 1972, information was received on the four alternative sites being reviewed by the State.

On February 23, 1973, public announcement was made concerning TVA's intention to construct a nuclear plant at the Hartsville site. On April 12, 1973, TVA met with State, regional, and local organizations and interested citizens to discuss the Hartsville site and the possible impacts if a nuclear plant is built there.

TVA is also subject to the provisions of the following requirements relating to the preservation of cultural, historical, archaeological, and architectural resources: The National Historic Preservation Act of 1966 (16 U.S.C. §§ 470-70n); Executive Order No. 11593 (3 C.F.R. 560 [1971]); and Public Law 93-291 (May 24, 1974).

On July 9, 1973, further comments were received from the State Historical Commission on the historical aspects of the Hartsville site and surrounding area. On August 9, 1973, TVA and State officials met in Hartsville to discuss and observe the significant historical structures in the area.

In mid-October 1973 TVA participated in a meeting with a large number of State and regional planning and assistance organizations to discuss assistance to the Hartsville area to absorb construction impacts. Approximately three months later on January 23, 1974, the manpower needs were discussed with the Mid-Cumberland Development District Manpower Planning Board.

In addition to the recorded consultations outlined above, TVA has held public information meetings in Lebanon, Carthage, Gallatin, Lafayette, and Hartsville.

In developing the proposed transmission line routes which are described in Section 3.9.3, preplanning discussions were held with the following

Federal and state commissions, departments, and planning agencies. Through the early disclosure of TVA's plans, potential conflicts with other agency programs or interests have been factored into the decision-making process. No major conflicts or environmental impacts were identified which may result from this project that cannot be reasonably controlled or avoided.

Upper Duck River Development Agency
Tennessee Department of Conservation
Federal Aviation Agency
Upper Cumberland Development District
U.S. Department of Agriculture, Soil Conservation Service
Tennessee Game and Fish Commission
Tennessee State Planning Office
South Central Tennessee Development District
Mid-Cumberland Council of Governments
Tennessee Department of Transportation

Within TVA, this project was developed in consultation with the following organizations.

Division of Water Control Planning
Division of Navigation Development and Regional Studies
Office of Tributary Area Development
Division of Reservoir Properties
Division of Forestry, Fisheries, and Wildlife Development
Division of Environmental Planning

In addition to meeting the requirements of NEPA, TVA is also required to obtain a permit under Section 402, National Pollutant Discharge Elimination System, of the "Federal Water Pollution Control Act Amendment of 1972." At the present time, there is no application for a permit under this Act.

In addition, a construction permit and operating license are required under the Atomic Energy Act of 1954 and 10 C.F.R. Part 50 for the construction and operation of the four units of the Hartsville Nuclear Plant.

Conclusion

This document reflects the manner in which TVA has incorporated environmental considerations into the decision-making and design processes.

The plant will interact with the environment in four principal ways: (1) release of minute quantities of radioactivity to the air and water, (2) release of minor quantities of heat to Old Hickory Reservoir and major quantities to the atmosphere, (3) release of minute quantities of chemicals to Old Hickory Reservoir, and (4) change in land use from farming to industrial.

Alternatives to minimize adverse environmental impacts have been considered for all systems having a potential for significant impacts, and alternatives were chosen to reduce impacts to a minimum practical level. In addition, construction methods will be employed which minimize adverse impacts.

The plant as now designed closely approaches a minimum impact plant and can be constructed and operated without significant risk to the health and safety of the public.

The addition of the Hartsville Nuclear Plant to the TVA system will enable TVA to continue to fulfill its statutory obligation to provide an ample supply of electricity for the TVA region.

After weighing the environmental costs and the technical, economic, environmental, and other benefits of the project and adopting alternatives which affect the overall balance of costs and benefits by lessening

environmental impacts, TVA has concluded that the overall benefits of the project far outweigh the monetary and environmental costs, and that the action called for is the construction and operation of the Hartsville Nuclear Plant.